Insects. No. 61. See mites 1.

Issued December 15, 1915.

United States Department of Agriculture,

OFFICE OF THE SECRETARY.

THE PROPERTY OF
THE WELLCOME BUREAU
OF SCIENTIFIC RESEARCH

Report No. 108.

[Contribution from the Bureau of Entomology, L. O. Howard, Chief.]

THE ACARINA OR MITES.

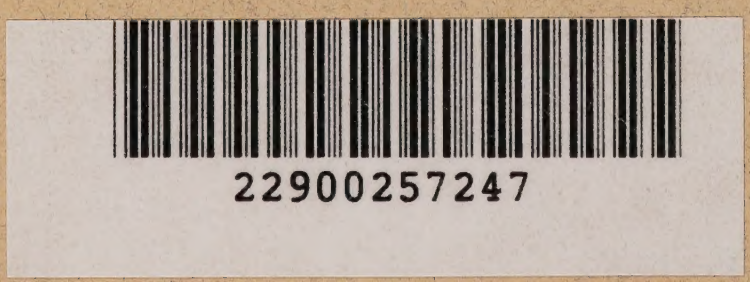
A REVIEW OF THE GROUP FOR THE USE OF ECONOMIC ENTOMOLOGISTS.

BY

NATHAN BANKS,

Entomological Assistant.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915.


22900257247

Med
K16853

Issued December 15, 1915.

United States Department of Agriculture,
OFFICE OF THE SECRETARY.

Report No. 108.

[Contribution from the Bureau of Entomology, L. O. Howard, Chief.]

THE ACARINA OR MITES.

A REVIEW OF THE GROUP FOR THE USE OF ECONOMIC ENTOMOLOGISTS.

BY

NATHAN BANKS,
Entomological Assistant.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915.

CONTENTS.

	Page.
Preface	7
Introduction	7
Synopsis of superfamilies	17
Synopsis of families	18
Eupodoidea	20
Eupodidæ	20
Cryptognathidæ	23
Bdellidæ	23
Trombidioidea	26
Cheyletidæ	26
Anystidæ	30
Tetranychidæ	32
Erythræidæ	38
Trombidiidæ	41
Cæculidæ	45
Hydrachnoidea	45
Hydrachnidæ	45
Halacaridæ	54
Ixodoidea	56
Parasitoidea	70
Spelæorhynchidæ	70
Holothyridæ	70
Parasitidæ	71
Oribatoidea	90
Oribatidæ	95
Hoplodermatidæ	102
Labidostommatidæ	103
Sarcoptoidea	104
Tarsonemidæ	104
Tyroglyphidæ	109
Canestriniidæ	118
Analgesidæ	119
Listrophoridæ	126
Sarcoptidæ	128
Cytoleichidæ	133
Demodicoidea	134
Eriophyidæ	134
Demodicidæ	139
Opilioacaridæ	140
Uncertain Acari	140
Collecting, preparing, and rearing mites	141
List of works useful in the study of American Acarina	143
Index and generic synonymy	147

WELLCOME INSTITUTE LIBRARY
Coll. welMOmec
Call No. QX

ILLUSTRATIONS.

TEXT FIGURES.

		Page.
FIG.	1. Dorsal view of a mite	8
	2. Ventral view of a mite	8
	3. Palpi of various forms	9
	4. Legs of various mites	10
	5. Anatomy of *Parasitus*	11
	6. Embryo of *Parasitus*	12
	7. A mite, *Trombidium:* Egg, larva, adult	13
	8. Venter of an eupodid	20
	9. A mite, *Alichus roseus*	20
	10. Cephalothorax of *Bimichaelia*	21
	11. Dorsal view of the mite *Notophallus*	21
	12. *Linopodes antennaepes*	22
	13. *Rhagidia pallida*	22
	14. *Tydeus:* Beak and leg I, from below.	22
	15. *Eupodes:* Legs I and IV	22
	16. *Erynetes concolor:* Tarsus and palpus	22
	17. *Teneriffia:* Palpus	23
	18. *Cryptognathus lagena*	23
	19. Venter of a *Bdella*	24
	20. Egg of *Bdella*	24
	21. *Bdella peregrina*	25
	22. *Bdella tenella*	25
	23. Mandibles and palpus of *Cunaxa*	25
	24. *Cheyletus* sp	26
	25. *Cheyletus pyriformis:* Beak and palpus, tip of leg I, and claws of leg II.	26
	26. *Cheyletus audax*, from below	27
	27. *Cheyletiella canadensis*	28
	28. *Cheletopsis nörneri*	28
	29. *Harpyrynchus longipilus:* Female	29
	30. *Harpyrynchus longipilus:* Larva	29
	31. *Psorergates simplex*	29
	32. *Myobia canadensis*	29
	33. *Picobia helleri*	30
	34. *Picobia helleri:* Tarsus and head	30
	35. Venter of *Anystis*	30
	36. *Tarsotomus spinatus*	31
	37. *Pterygosoma texana:* Adult and details	31
	38. *Tetranychus bimaculatus*	32
	39. Details of *Tetranychus*	32
	40. Details of *Tetranychus*	33
	41. Leg of *Tetranychus*	33
	42. Genital organs of *Tetranychus*	34
	43. Claws of *Tetranychus*	34
	44. *Tetranychus gloveri:* Palpus and mandibular plate	34
	45. *Bryobia pratensis:* Female and details	35
	46. *Bryobia pratensis:* Larva	36
	47. *Stigmaeus floridanus:* Adult and details	36
	48. *Acheles*	37
	49. *Tetranychoides californica* and palpus	37
	50. *Raphignathus brevis*	37
	51. *Tetranychopsis spinosa*	37
	52. *Tenuipalpus californicus*	38
	53. *Neophyllobius americanus* and claw.	38
	54. Details of *Erythraeus*	39
	55. *Atomus maculatus*	39
	56. Leptus of *Erythraeus* on a plant louse	39
	57. *Erythraeus simplex* and palpus	40
	58. Venter of *Smaris*	41
	59. *Caeculisoma:* Tarsus I	41
	60. Egg of *Trombidium*	41
	61. Eye of *Trombidium*	41
	62. Claws of *Trombidium*	41
	63. Leg I of *Trombidium*	42
	64. Mandible and details of *Trombidium*	42
	65. Larva (leptus) of a *Trombidium*	42
	66. Larva of *Allothrombium* and mouth parts	43
	67. Larva of *Trombidium* from cricket	44
	68. *Trombidium locustarum*	44
	69. Palpus of *Trombidium giganteum*	44
	70. Palpus of *Trombidium magnificum*	44
	71. *Caeculus americanus*	45
	72. *Limnochares:* Venter	46
	73. *Limnochares:* Eyes and dorsal plate	46
	74. *Eylais* sp	46
	75. *Eylais:* Eye plate	46
	76. Genital suckers of hydrachnids	47
	77. *Arrenurus* sp: Male	47
	78. *Arrenurus* sp: Palpus	50
	79. *Arrenurus* sp: Female from below	50
	80. Larva of a hydrachnid	50
	81. Larva of *Hydrachna* attached to leg of an insect; nymph inside	51
	82. *Limnesia* sp.: Palpus and coxal plates	51
	83. *Tyrrellia circularis*	51
	84. *Thyas* sp	51
	85. Mandible of *Thyas* sp	51
	86. Palpus of *Thyas* sp	51
	87. Coxal plates of *Hygrobates*	52
	88. Palpus of *Hygrobates*	52
	89. Palpus of *Atractides*	52
	90. Coxal plates of *Sperchon*	52
	91. Palpus of *Sperchon*	52
	92. Venter of *Lebertia*	52
	93. *Piona* sp., and palpus above	53

Page.

FIG. 94. *Piona* sp.: Larva 53
95. *Atax* sp 53
96. Coxal plates of *Atax* 53
97. Tarsal claw of *Atax* 54
98. Palpus of *Atax* 54
99. Claws of *Halacarus* 54
100. *Halacarus* sp 55
101. *Scaptognathus* sp 55
102. *Simognathus* sp 56
103. *Argas miniatus*, from below 56
104. *Otobius megnini:* Nymphal form and details 56
105. *Ornithodoros turicata* 57
106. *Ixodes* and *Dermacentor:* Ventral furrows 57
107. Hypostome and mandibles of a tick. 58
108. *Ixodes, Margaropus, Amblyomma, Dermacentor, Hæmaphysalis*: Stigmal plates 58
109. Shield of *Margaropus annulatus*, female 59
110. *Margaropus annulatus:* Male 59
111. *Margaropus annulatus:* Larva 59
112. *Margaropus annulatus:* Claws 60
113. *Margaropus annulatus:* Egg 61
114. *Dermacentor variabilis:* Male 61
115. *Dermacentor variabilis:* Shield of female 62
116. *Dermacentor:* Tarsus IV 62
117. *Dermacentor albipictus:* Male 63
118. *Rhipicephalus sanguineus:* Shield of female 63
119. *Rhipicephalus:* Palpus 64
120. *Rhipicephalus:* Shield of nymph 64
121. *Rhipicephalus pulchellus:* Male 64
122. *Amblyomma americanum:* Engorged female 65
123. *Amblyomma cajennense:* Shield of female 65
124. *Amblyomma:* Shield of nymph 66
125. *Amblyomma:* Tarsus IV 67
126. *Haemaphysalis chordeilis:* Shield of female 67
127. *Ixodes:* Head 68
128. *Ixodes:* Details of Leg I 68
129. *Ixodes scapularis:* Shield of female .. 68
130. *Ixodes marxi:* Female 69
131. *Ixodes:* Venter of male 69
132. *Ceratixodes:* Palpi of male and female 70
133. *Spelaeorhynchus praecursor* 70
134. *Holothyrus* 70
135. *Parasitus:* Venter 71
136. *Parasitus:* Side view 71
137. *Spinturnix americanus* 72
138. *Spinturnix:* Venter 72
139. *Periglischrus jheringi:* Female 73
140. *Sternostomum rhinolethrum* 73
141. *Pneumonyssus simicola* 74
142. *Pneumonyssus simicola:* Larva 74
143. *Pneumonyssus:* Details 75
144. *Halarachne americana:* Details 75
145. *Dermanyssus gallinæ* 76
146. *Dermanyssus gallinæ:* Details 77
147. *Liponyssus americanus* 77
148. *Liponyssus:* Details 77

Page.

FIG. 149. *Haemogamasus americanus* 78
150. *Rhodocarus roseus* 78
151. *Megisthanus floridanus* 79
152. *Iphiopsis* sp., caroncle and peritreme 80
153. *Macrocheles carolinensis:* Female ... 81
154. *Macrocheles carolinensis:* Venter of female 81
155. *Macrocheles spinatus:* Legs II and IV of male 81
156. *Caelenopsis americana* 82
157. *Sejus americanus* 82
158. *Paragreenia alfkeni* 82
159. *Laelaps echidninus* 82
160. *Parasitus* sp 83
161. *Parasitus* sp.: Nymph 83
162. *Parasitus* sp.: Larva 83
163. *Parasitus calcarator* 83
164. *Parasitus predator:* Leg II of male .. 84
165. *Hyletastes* sp.: Adult and anal plate. 84
166. *Hyletastes ovalis* 85
167. *Seiulus quadripilis* 85
168. *Hypoaspis mexicanus* and details ... 86
169. *Hypoaspis macropilis* and details ... 86
170. *Antennophorus uhlmanni* 87
171. Ant carrying three Antennophori .. 87
172. *Uroplitella:* Details 88
173. *Uropoda:* Details 88
174. *Uropoda* sp. and pedicel 89
175. *Uropoda* sp 89
176. *Cilliba hirsuta* 89
177. *Dinychus americanus* 90
178. Details of an oribatid 91
179. Mouth parts of an oribatid 91
180. *Galumna* sp 92
181. *Galumna* sp: Nymph 92
182. *Galumna hubbardi* 92
183. *Galumna persimilis* 92
184. *Oribatella valida* 93
185. *Oribatella armata* 94
186. *Oribatella* sp 94
187. *Liacarus nitidus* 95
188. *Liacarus carolinensis* 97
189. *Liacarus* sp: Nymph 97
190. *Oribella pilosus* 97
191. *Notaspis montana* 97
192. *Gymnobates glaber* 98
193. *Oripoda elongata* 98
194. *Carabodes lamellatus* 98
195. *Oribata gracilipes* 99
196. *Oribata* sp.: Venter 99
197. *Oribata* sp.: Claw 100
198. *Oribata* sp.: Larva 100
199. *Oribata minuta* 100
200. *Carabodes brevis* 100
201. *Cepheus marginalis* 100
202. *Scutovertex petrophagus* 100
203. *Neoliodes concentricus* 101
204. *Nothrus* sp.: Venter 101
205. *Nothrus banksi* 101
206. *Nothrus truncatus* 101
207. *Nothrus taurinus* 101
208. *Hypochthonius texanus* 102
209. *Hoploderma sphaerula* 102
210. *Phthiracarus* sp.: Closed up; ventral view 102

		Page.
FIG. 211.	*Labidostomma cornuta*	103
212.	*Labidostomma cornuta:* Venter	103
213.	*Pediculoides* sp.: Beak and claw	104
214.	*Pediculoides ventricosus:* Female	104
215.	*Pediculoides ventricosus:* Male	104
216.	*Pediculoides ventricosus:* Gravid female	105
217.	*Siteroptes carnea* and claw	105
218.	*Tarsonemus pallidus*	106
219.	*Tarsonemus latus:* Female	106
220.	*Tarsonemus latus:* Male	107
221.	*Tarsonemus* sp	107
222.	*Podapolipus* sp.: Male and female	107
223.	*Pigmeophorus americanus* and details	107
224.	*Pigmeophorus americanus*	108
225.	*Scutacarus americanus,* from below, and claw	108
226.	*Imparipes* sp	108
227.	*Tyroglyphus* sp	109
228.	Hypopus of a *Tyroglyphus,* from below	110
229.	*Histiostoma americana*	110
230.	Beak of *Histiostoma americana*	111
231.	Leg I, and tip of mandible of *Histiostoma americana*	111
232.	*Glyciphagus obesus*	111
233.	*Labidophorus sciurinus:* Male	112
234.	*Carpoglyphus passularum:* Male	112
235.	*Aleurobius farinae:* Details	114
236.	*Tyroglyphus lintneri:* Female	114
237.	*Rhizoglyphus rhizophagus*	115
238.	*Rhizoglyphus hyacinthi,* side view	115
239.	*Monieziella* sp.: Female	116
240.	*Monieziella* sp.: Mandible and venter	117
241.	*Monieziella* sp., from San Jose scale	117
242.	*Histiogaster xylophaga*	117
243.	*Trichotarsus xylocopae:* Nymph and claw	118
244.	*Canestrinia* sp.: Female, from below	118
245.	*Hemisarcoptes malus:* Female	119
246.	Details of an analgesid	120
247.	Caroncle of *Pterolichus*	120
248.	Leg of *Analges*	120
249.	*Pterolichus* sp. (near *delibatus*), on condor	121
250.	*Hypoderas columbae,* a stage of *Falculifer*	121
251.	*Alloptes microphaethon* and caroncle	123
252.	*Analges passerinus:* Female	123
253.	*Analges passerinus:* Male	124
254.	*Megninia tyrrelli*	124
255.	*Megninia albidus*	124
256.	*Pteronyssus tyrrelli*	124
257.	*Allanalges gracilepinnatus*	125
258.	*Pterodectes armatus*	125
259.	*Rivoltasia bispinosa*	126
260.	*Schizocarpus mingaudi:* Female	126
261.	*Schizocarpus mingaudi:* Male and female	127
262.	*Myocoptes* clinging to a hair	127
263.	*Listrophorus validus*	128
264.	*Sarcoptes scabei:* Male	128
265.	*Sarcoptes scabei:* Female	128
266.	Leg of a *Sarcoptes*	129
267.	*Sarcoptes* in her burrow, and eggs	129
268.	*Psoroptes communis* var. *ovis:* Male	130
269.	*Psoroptes communis* var. *ovis:* Female and caroncle	130
270.	*Chorioptes setiferus*	131
271.	*Notoedres muris*	131
272.	*Otodectes cynotis:* Female	132
273.	*Otodectes cynotis:* Tip of male abdomen, and hind legs	132
274.	*Cnemidocoptes mutans:* Female	132
275.	*Cytoleichus nudus*	133
276.	*Laminosioptes cysticola*	133
277.	*Eriophyes* sp., side view	134
278.	Egg of an *Eriophyes* in gall	134
279.	*Eriophyes gossypii:* Anterior part of body	135
280.	A dimple gall	135
281.	A capsule gall	135
282.	A pouch gall	135
283.	A nail gall	136
284.	A blister gall	136
285.	Nail galls of an *Eriophyes*	136
286.	Rib galls of an *Eriophyes*	137
287.	Section of an erinium on leaf	137
288.	Round galls of an *Eriophyes*	138
289.	*Eriophyes vitis*	138
290.	*Phyllocoptes* sp., side view	139
291.	*Demodex folliculorum*	139
292.	*Porocephalus* sp	140
293.	A tardigrade	140
294.	*Nymphon,* a pycnogonid	141

THE ACARINA OR MITES.[1]

By Nathan Banks,
Entomological Assistant, Bureau of Entomology.

PREFACE.

The mites have always attracted considerable interest, both from their minute size and because of the remarkable habits of some species. Although many persons have examined them in a desultory way, but few have really studied them. Consequently there is a great amount of literature, much of which is not reliable. Too often entomologists have considered that their knowledge of insects in general was a sufficient basis for the description of mites. Probably the lack of general works on mites has been responsible for many errors. For years the only work treating of the mites as a whole that has been accessible to American naturalists is Andrew Murray's Economic Entomology; Aptera (1877). In this book nearly 300 pages are devoted to Acarina. Unfortunately Murray's treatment is far from satisfactory and abundantly stored with mistakes, many, however, taken from other writers.

Since that book was published several European specialists have been at work on the European fauna and produced monographs which are of great accuracy. Not only have various new facts been discovered, but many of the old facts have been given quite new interpretations. Such a belief as the parasitism of the *Uropoda* on the Colorado potato-beetle seems hardly as yet to have been eradicated. To present a reliable text to the American reader is my intention. Very frequently I have obtained facts of importance and interest from the European literature. Particularly is this true with those parasitic groups with which I am not so well acquainted. Errors will of course be found, but great care has been exercised in choosing the sources of information.

I have given tables to all the known American genera, and in some families added other well-known genera which will doubtless occur in our fauna when it is more thoroughly explored.

Practically the only door through which one may enter into the systematic study of mites in general is Canestrini's Prospetto dell' Acarofauna Italiana; but for certain families there are other works, which will be found listed in the bibliography.

INTRODUCTION.

The acarians form an order in the great class Arachnida. They are thus related to spiders, daddy-long-legs, and scorpions. A few writers at various times have claimed that the mites were a separate class, but the best sense of modern authors is that they are genuine arachnids, and in many ways closely related to solpugids and phalangids. Dugès was the first to see their relation to phalangids, a view which is now generally held by acarologists. Dugès divided all arachnids into two subclasses: Hologastra for

[1] In 1904 there was published in the Proceedings of the U. S. National Museum a work entitled "A Treatise on the Acarina or Mites." In the practical absence of available information on mites it was found especially useful to economic entomologists and teachers. As it has long been out of print and the demand for it continues, the author has revised and enlarged the original work, bringing it up to date and adding many new illustrations, so that this is better considered a separate work.

the mites, and Tomogastra for the other arachnids. Thorell pointed out the relation of certain eupodid mites to the Solpugida, and this is, I think, the correct solution of the position of the Acari.

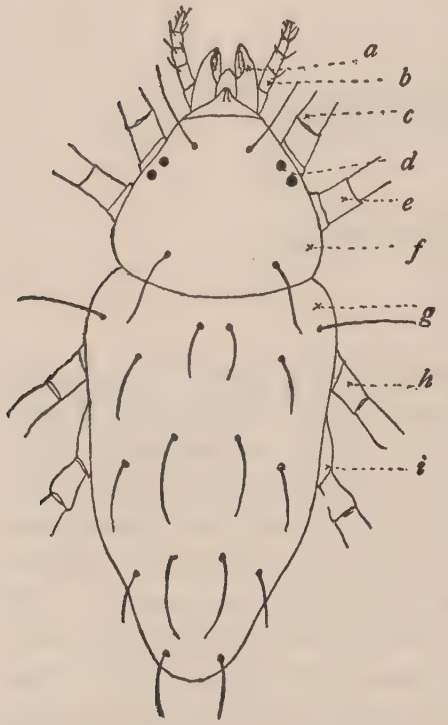


FIG. 1.—Dorsal view of a mite: *a*, Mandibles; *b*, palpi; *c*, leg I; *d*, eyes; *e*, leg II; *f*, cephalothorax; *g*, abdomen; *h*, leg, III; *i*, leg IV. (Author's illustration.)

Although quite easily recognized at sight, it is not easy to give definite characters whereby to distinguish a mite from other arachnids. The abdomen (fig. 1) and cephalothorax are broadly united to each other, and often there is no distinction between these parts. Usually there is no trace of segmentation, but in some forms it is quite distinct. Eyes are often present, but rarely only a median pair, as we find in phalangids and solpugids. The mouth segments have become united to form a beak, rostrum, or capitulum. However, this is not easily made out in some forms. Commonly the larva at birth has but three pairs of legs, and obtains the fourth pair only after a molt and metamorphosis. In the Eriophyidæ, however, there are but two pairs of legs in both adult and young, and in *Pteroptus* the young have eight legs at birth. The adult mite has (except in the Eriophyidæ) four pairs of legs; often arranged in two groups, the hinder pairs apparently arising from the abdomen. However, it is not probable that such is the case; rather the coalescence of the abdomen and cephalothorax has effaced the true outlines of these portions. It is probable that the abdomen of mites is more than the abdomen of other arachnids. If one examines a *Solpuga*, he sees that the cephalothorax is divided into several portions, and it may be that the cephalothorax of mites represents only the anterior of these, while the abdomen of mites represents the abdomen of *Solpuga* plus the two posterior divisions of the cephalothorax. In *Tarsonemus* and some other genera the abdomen shows on the dorsum distinct traces of segmentation. On the venter (fig. 2) there is still less distinction between parts, and in several groups, as Ixodidæ and some Parasitidæ, the genital segment is pushed forward so far that the genital aperture is close to the mouth. In other forms the genital opening is at the extreme tip of the body, and the anus is upon the dorsum.

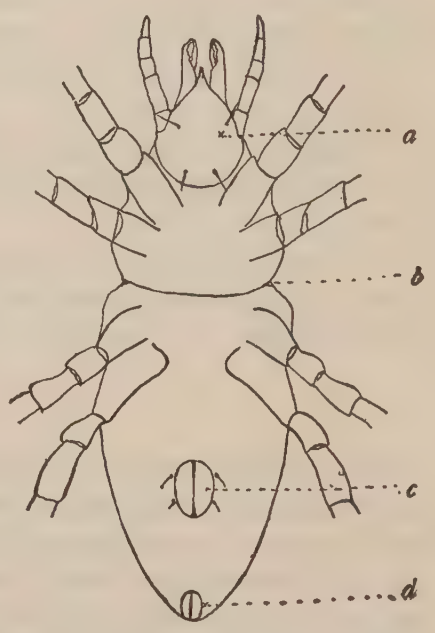


FIG. 2.—Ventral view of a mite: *a*, Beak; *b*, transverse furrow; *c*, genital aperture; *d*, anal aperture. (Author's illustration.)

The cephalothorax, prosoma, or anterior part of the body commonly has one or more pairs of simple ocelli-like eyes. They are usually sessile, but sometimes elevated on pedicels.

The mouth segments form typically a truncate cone or beak. Sometimes it is partially or completely retracted into the body. The mouth parts are the mandibles and palpi. Frequently there are other parts, as a hypopharynx, a lip, or definitely separated maxillæ, as will be mentioned under each family. Several investigators have claimed that there are three or four mouth appendages, and there are structures in some forms that indicate three. The mandibles generally are of two joints.

The last is often opposable to a projection of the preceding, so as to become chelate. However, in many forms the mandibles are slender, needle-like, and suited for piercing. In each of the three large families (Oribatidæ, Parasitidæ, and Tyroglyphidæ) which typically have chelate mandibles there is one genus with styliform piercing mandibles. The palpi have never more than five joints; the last is frequently provided with peculiar sensory hairs. In some cases the palpi have a geniculate attitude. The various forms of palpi (fig. 3) may be grouped into four classes: (1) Where they are simple, filiform, and have a tactile function; (2) where they are modified for predatory purposes, being provided with spines, hooks, or claws; (3) where the last point is opposable to the preceding, so that the mite may by its palpi cling to some object; (4) where they have become obsolete and are more or less united to the rostrum. The basal joints of the palpi are at times differentiated to form maxillæ.

In several families there is a distinct lingula, tongue, or hypostome, which arises from the inner base of the beak and may be divided or simple. It may have a groove above, called the vomer. The hypostome is usually not visible except by dissection, but in the ticks it is very large and roughened with sharp teeth.

Sometimes the basal joints of the palpi unite to form a lip or labium. Above the mandibles in many forms is a thin corneous plate, known as the epistoma. Its sides may be partly united to the beak or lip below and thus form a tube, called the oral tube, for it is through it that the mandibles are protruded.

The pharynx or sucking portion of the alimentary tract is sometimes prolonged forward into a sort of cone between the mouth parts.

FIG. 3.—Palpi of various forms: *a, Bdella; b, Cheyletus; c, Gamasus; d, Scirus; e, Histiostoma; f, Eupodes; g, Sarcoptes; h, Arrenurus; i, Trombidium.* (Author's illustration.)

The opening of the body into which the mouth parts are inserted is known as the camerostome. In one group (*Uropoda*) the anterior legs are also inserted into this camerostome.

The adult mite as a rule has four pairs of legs and the larva three pairs. It has been shown that the embryo of certain forms (Parasitidæ and *Ixodes*) has four pairs of legs before birth, but one pair is aborted, to be again developed at the nymphal stage. This is an indication that the six-legged larva is a secondary development and lessens the apparent difference between Acarina and other Arachnida. The legs (fig. 4) are composed of from five to seven segments; in some forms the apical joints are subdivided but do not form genuine segments. The length and character of the joints vary in the different families, but usually there are distinguishable the following parts: Coxa, trochanter, femur, patella, tibia, and tarsus. In some cases the femora are divided into two parts, or there is a suture near the base indicating a trochantin. The legs are provided with hairs and spines, sometimes modified for some particular function. In several groups there are organs on the anterior legs which appear to have a sensory function. The last joint or tarsus is commonly ter-

minated by from one to three claws or ungues. In some groups there is a difference in this respect between the young and the adult, and frequently one or more pairs of legs are destitute of claws. The claws are not often toothed. In many cases there is a median cup-shaped sucker, pulvillus, caroncle, or ambulacrum between the claws or bearing them.

The reproductive organs, as in other arachnids, open on the ventral surface of the abdomen near the base. The female aperture (vulva or epigynum) is of various shapes and sometimes closed by flaps or folding doors. The male aperture (epiandrum) is usually smaller than that of the female. The body is often provided with hairs, bristles, or scales, which are of characteristic nature and arrangement in each species.

In many of the soft-bodied forms there are chitinous plates, scutæ, or shields, sometimes so large or so numerous as almost completely to cover the mite. These

FIG. 4.—Legs of various mites. (Author's illustration.)

shields are often sculptured or pitted in a characteristic manner. Frequently there are secondary sexual differences both of color and structure, as will be noticed under each family. The male is often a little smaller than the female, but in many cases there is no apparent difference in size.

The internal anatomy (fig. 5) of mites is marked by great centralization of parts, the various organs being much more crowded together than with other arachnids. The alimentary canal when fully developed consists of the pharynx or sucking organ; the œsophagus; the stomach or ventriculus, with its cœca; the hind gut or intestine, and the Malpighian vessels, which enter the latter near the rectum.

The pharynx is a partially chitinous tube, convex below, concave above; to its upper part or roof are attached the muscles which, upon contracting, elevate the roof. A series of muscles, each moving just after the one in front, produces a steady flow of food to the stomach. The œsophagus is a long simple tube; the stomach is of varied size and shape, according to the food habits. Sometimes there is an enlargement of the œsophagus near its end, thus forming an ingluvies or crop. In some forms the cœca are extremely long or numerous. The Malpighian vessels, when present, are two in number, and enter the short intestine near its end. The latter is sometimes provided with an enlargement, the colon. In many mites the digestive system is much simplified. In many, if not all, of the forms allied to *Trombidium*, and the water

mites, there is no certain connection between the stomach or ventriculus and the anus. The ventriculus ends blindly; the anus opens into a large tube, supposed to have an excretory function. Many of these forms feed on animal juices, so probably have no excreta.

The nerve ganglia are united into one mass of considerable size, pierced by a hole for the œsophagus. This brain doubtless is formed by the union of the supra- and subœsophageal ganglia and their commissures, but so closely are the parts united that all trace of demarcation is commonly lost. The principal nerves arise from this brain. There is one unpaired nerve and nine or more pairs of nerves. Three sets of paired nerves and the unpaired one arise from the supraœsophageal ganglion and are of small size. The other six or more sets of paired nerves arise from the subœsophageal ganglion and are mostly of larger size. The unpaired, or median nerve, goes to the pharynx. The paired nerves of the supraœsophageal ganglion go to the eyes, the mandibles, and the large vertical muscles near the base of the rostrum. Of the nerves of the subœsophageal ganglion, one pair goes to the palpi, four to the legs, and one to the

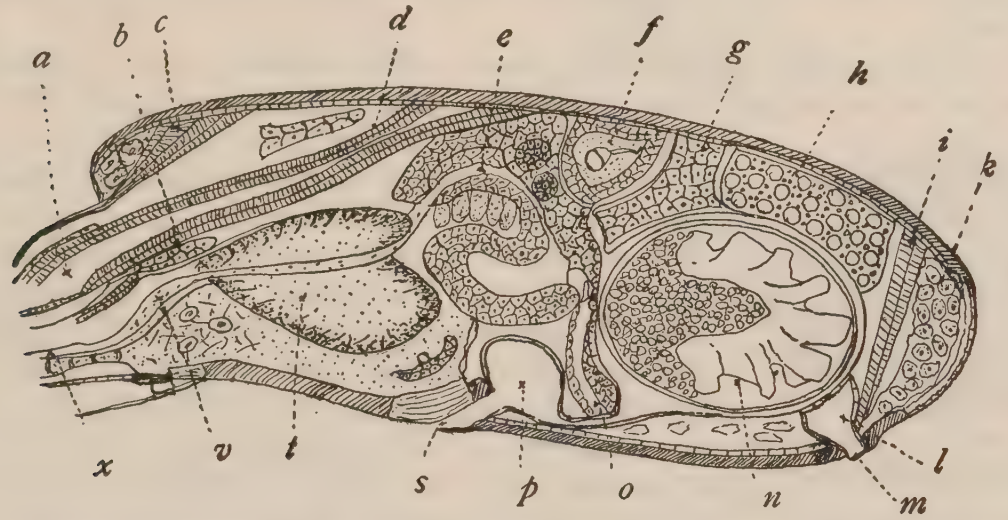


FIG. 5.—Anatomy of *Parasitus: a*, Mandible; *b*, salivary gland; *c*, retractor rostrum; *d*, muscles of mandibles; *e*, ventriculus; *f*, sacculus fœmineus; *g*, lyrate organ; *h*, ova; *i*, levator ani; *k*, fat cells; *l*, cloaca; *m*, anus; *n*, embryo; *o*, hind gut; *p*, vagina; *s*, vulva; *t*, brain; *v*, œsophagus; *x*, pharynx. (Author's illustration.)

genital and other abdominal organs. Sometimes there are other nerves that extend to the posterior part of the body.

The reproductive system is often highly developed and frequently occupies a considerable part of the body. The testes of the male are large, lobate, and open into two tubes, the vasa deferentia, which, uniting to form the ductus ejaculatorius, may open through an extensile penis. The ovaries (sometimes united) are situated in the middle part of the body, are of varying shape, and open into two tubes—the oviducts—which unite to form the vulva. The latter may have a spermatheca attached, and may open through an extensible ovipositor. In some families the vulva is not a bursa copulatrix, but there is a special copulatory opening near the anus. In other forms the female organs are very different, as will be mentioned under the families.

In the Parasitidæ, Tyroglyphidæ, and Oribatidæ there are a pair of glands in each side of the abdomen, each opening by a pore in the skin. They contain a yellowish, oily liquid, and are considered excretory glands; Michael has called them "expulsory vesicles." In most mites there are several glands in the head region, some of them evidently of a salivary nature, but others are often present whose function is unknown. Some of them open into the mouth, or pharynx, and others may open at the base of the mandibles.

In the Prostigmata, Thor has found as many as seven kinds of glands, one pair of which are often longer than the entire body. There is also a median unpaired gland

in these forms. Doubtless the secretions from each kind of gland is peculiar and for some special purpose. In the Metastigmata and Oribatidæ there are very few, usually none, of these salivary glands; in the Tyroglyphidæ and Sarcoptidæ there are usually one or two pairs.

In some mites there is a well-developed dorsal pulsating organ or heart, but in most mites it is not present. In these latter there is an irregular motion of the body fluids, kept up by the action of the muscles in other movements. Many mites have an elaborate tracheal system for breathing. The tracheæ open in various parts of the body; in many common forms they open near the mandibles. In ticks and parasitids they open near the hind legs. In other forms they open in the acetabula or coxal cavities. The opening of the tracheæ are through stigmata or spiracles which vary in different forms. Commonly there are one or two main tracheal trunks in each side of the body, each giving off many branches. In some forms there is a short tracheal trunk which at its tip gives rise to a great number of fine long tracheæ, each of which is unbranched. Many mites, however, have no internal respiratory system whatever, and in these forms the skin is soft, and they absorb oxygen by osmosis through the general surface of the body.

The muscular system of mites varies greatly in the different genera. Strong muscles are attached to the mandibles for extending and moving these organs. Still more powerful ones are attached to the legs, and those for the pharynx and organs of generation are often prominent. There are also muscles connecting various parts of the integument and in some cases one or two pairs attached near the middle of the dorsum. These latter often produce the depressions in the dorsal surface which are commonly found in many of the soft-bodied mites. Thor has studied the structure of the skin of various mites, and separates at least three layers, the outer, called epiostracium, an inner layer, ectostracium, and the innermost, the hypoderm. The body and appendages of mites are clothed more or less thickly with hairs of various kinds. Usually some are stout and form spines; others are feathered, others clavate or scalelike; some are very long and delicate; some are movable, some arise from pores, and many have nerve connections. Haller has attributed to them functions of touch, hearing, and smell, but with little, if any, evidence. In a number of water mites hairs are sometimes developed in tufts on the legs and aid the creature in swimming. In a few cases there are sexual differences in the hairs.

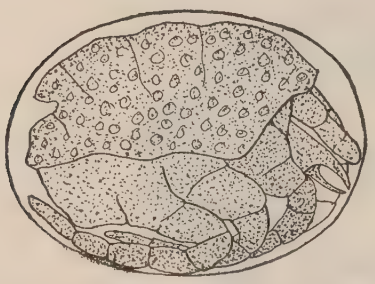


FIG. 6.—Embryo of *Parasitus*. (Author's illustration.)

The life histories of mites are extremely variable, and will be described under each family. There are typically four stages—egg, larva, nymph, and adult or prosopon. Many mites, however, have developed a more complicated arrangement of forms that almost obscures this fundamental simplicity. Most of these additional phases occur during the nymphal stage, the growing stage of the acarian.

Nearly all mites deposit eggs, but there are a few forms known to be viviparous, or at least ovoviviparous, and one, *Pediculoides*, brings forth adult males and females.

The normal plan of development is as follows: The egg is usually deposited by the female. Often within this egg, while the embryo (fig. 6) is developing, an inner membrane is formed which incloses the young mite; this stage is the "deutovum." The outer shell may be cracked so as to show the membrane, or it may be wholly discarded. The larva at birth has but six legs. It feeds for a while, then passes into a resting stage which in time discloses the eight-legged nymph. The added pair of legs is the fourth, at least usually. During the nymphal period the mite may molt one or more times and change its appearance, but is always destitute of true genital orifices. At the end of the nymphal stage it passes again into a quiescent condition, and in due time molts into the adult mite (fig. 7). During these resting stages much of the internal anatomy of the mite may undergo histolysis, each new stage being

rebuilt from the disintegrated tissues of the preceding stage. The genital organs are, however, not affected by these histolytic processes.

Reuter has recently (1909) tabulated the known life histories of mites, showing that most species have three nymphal stages. In several cases the second stage is absent or has not been observed; in most of the sarcoptid mites there are but two nymphal stages, while in the Eriophyidæ and Ixodidæ there is but one nymphal stage.

Various authors have expressed their belief in parthenogenesis in Acari, but without experimentation. Miss Foa and Dr. Oudemans have examined most of the alleged cases and show that there is no direct evidence, or that there has been a mixture of species, as in Trouessart's theory of the parthenogenesis of *Syringobia*. It was also held that *Syringophilus* was a parthenogenetic form of *Cheyletus nörneri;* Dr. Oudemans has shown that this is erroneous, and Nörner described the males of *Syringophilus*. The cases given by Berlese in the Parasitidæ were examined by Miss Foa, who concluded that there was no proof, for at the proper season the male of each species appeared, although in some species they live but a brief time. There is, therefore, no positive proof of parthenogenesis in acarians unless recent claims for parthenogenesis in a tick should prove to be true.

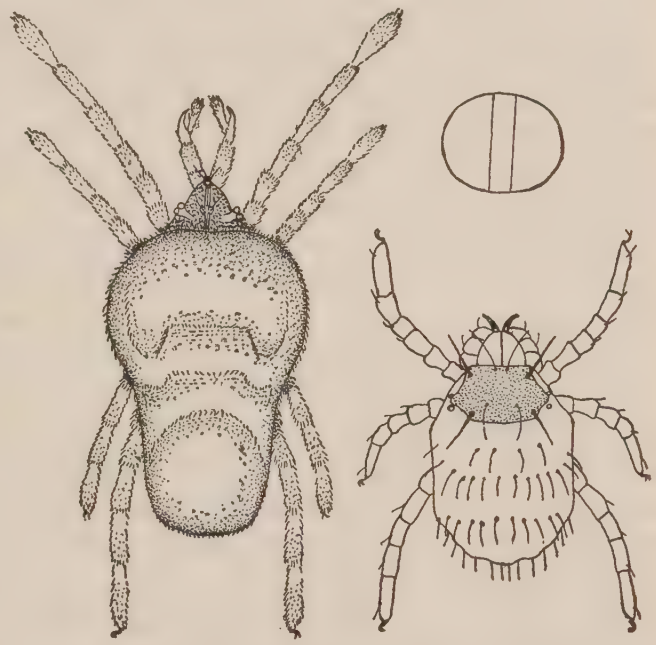


FIG. 7.—A mite, *Trombidium:* Egg, larva, and adult. (Original.)

The common impression that most mites are parasitic is entirely erroneous. About half of the known species are not parasitic in any stage, and many which are found attached to insects and other animals are not true parasites thereon. The relation between the host and the parasitic acarian is of such a varied nature that several writers have made elaborate classifications of their relationships. But, as with most classifications, there are intermediate forms.

It is evident that the parasitic habit has originated independently a number of times in mites, since in several families of mostly free-living forms there are parasitic genera. Also there is a different method of origin of parasitism in the different cases. Many free-living parasitids occur in nests of small mammals, finding there an abundance of food in the decaying matter, or small insects; so it is not strange that some parasitids (*Laelaps*, etc.) feed on the animal itself. Other parasitids have the habit of using various insects as a means of transportation from one breeding place to another suitable locality. Some of these mites, finding on the carriers an attractive food, have started a line of forms parasitic on insects.

Certain species of Tyroglyphidæ occurring on the bark of trees have had the opportunity to attack scale insects, and so developed genera usually predaceous on scale insects or their eggs. The ladybird beetles, being numerous about scale insects, were utilized by the mites for transportation; thus some of these mites, finding the ladybird beetles a suitable food, originated another group (*Canestrinia*), parasitic on these and other beetles. Some species are very restricted in the matter of hosts; others will attack almost anything. Those forms that attach by their beaks to suck blood are general feeders; those that have some specialized apparatus of legs or palpi to hold to their host can have but little range in host. Thus few ticks are confined to any one kind of animal, and frequently the young are found on a different host than that attacked by the imago. Many of the red bugs will attack any living thing, but on

man meet with death Likewise many of the water mites will attach to adult insects which leave the water, thus insuring their own destruction. This readiness to attach to various hosts prevents the multiplication of species, and gives each a fair certainty of life without the development of specialized characters.

There are many curious cases of parasitism whose origin can only excite our wonderment. The Dermanyssinæ are parasitic on the skin of birds, mites, bats, etc. But certain allied genera are internal parasites in very widely different animals; thus one (*Sternostomum*) is found in the nasal cavities of certain birds, another (*Halarachne*) in the bronchial passages of seals, and a third (*Pneumonyssus*) in the lungs of monkeys, while an undescribed form I have seen is from the air sac of a snake. The few forms of the small family Anystidæ are predaceous and run very rapidly in search of prey; but one genus has become parasitic on lizards and snakes.

We can only explain these remarkable habitats by the fact that mites, especially in their immature stages, have an uncontrollable desire to go somewhere, and get into every cavity and crack they discover in their wanderings. When hungry they test their locality for food, and if not too different from their previous diet this new habitat may result in new species and genera.

Most mites ordinarily move quite slowly, but when disturbed some can travel at an astonishing pace. A very few species are fitted for leaping. Aquatic mites occur in both fresh and salt water. Ticks occur on mammals, birds, and even on snakes and turtles. The bird mites live on the feathers and skin of birds; the itch mites burrow within the skin of man and other mammals. Other species live in the cellular tissue of birds; a few occur in the tracheal passages of seals, and several have been found living within the lungs of monkeys. Many species feed on living plants, and the gall mites produce curious deformations on leaves and twigs which attracted the attention of the early botanists, who described them as new genera and species of fungi.

Although mites are perhaps not as abundant in species as some would suppose, yet by the enormous multitude of individuals they largely make up for their small size. Trees infested by gall mites or red spiders may have many million specimens on their leaves; an animal infested by mites may support thousands of individuals, and stored food products attacked by tyroglyphids are often actually alive with immense hordes of these pests.

Mites are distributed throughout the globe, but appear to be most numerous in temperate regions. The acarid fauna of countries outside of Europe is only very incompletely known, but from what is known it seems probable that mites are as easily distributed as any animals. Most of the exotic mites belong to genera well known in Europe, but there are some remarkable forms, and, particularly in the Australian region, there are peculiar genera. Most of the parasitic forms are not confined to one species of host, so that their range may be greater than that of any one of their hosts. Those occurring on domestic animals, on cultivated plants, or on foods become cosmopolitan. Their minute size seems in no way to hinder their distribution. The existence of a migratorial stage in the Tyroglyphidæ and many Parasitidæ enables these forms to spread very rapidly. Many forms are not easily susceptible to cold or moisture, so they may extend far into the north and up high mountains. The species occurring in caves are mostly of the more primitive groups, as Eupodidæ and Parasitidæ. The mites found only under special conditions, as in ants' nests, are limited in distribution.

In Europe the English, Italian, and Dutch acarid faunas are fairly well studied; and considerable is known of the French, German, Austrian, and Swedish faunas. The forms that live in low and damp situations, as Eupodidæ, *Nothrus*, etc., are common in northern regions, while those fond of drier places, such as *Oribata* and *Rhyncholophus*, are more abundant in the south of Europe. The large family Parasitidæ seems to be fairly abundant in northern regions, but rather more numerous, and with greater variety of genera in the south. The ticks are by far most numerous in the Tropics, and very few species occur in northern localities. Some species of water mites occur in

widely separated regions, and it appears that water birds are partly responsible for their distribution.

In our country the mites of New York, Virginia, and Illinois are fairly well collected, but from what we know of the western species there is no reason to suppose they are more closely related to the European fauna than are those of the Eastern States.

Of the exotic mites the Ixodidæ and Analgesidæ are mostly described; of the other families very few; but Berlese has lately published many new species, largely of the Parasitidæ.

In the vicinity of any one locality in the temperate regions one may expect to find from 300 to 500 species of mites. Trägardh, who has studied the vertical distribution of mites on a mountain in Sweden, finds that the mites are fewer in number and in species as one ascends, and that in the low birch zone there are many mites in moss and among dead leaves, while in the lichen zone the great proportion are under stones. In the birch zone the predaceous species are in the ascendency, but in the willow and lichen zones the herbivorous species are most abundant. In going up the mountain the Oribatidæ decrease the least in species and in specimens, the Trombidiidæ next, and the Parasitidæ decrease very rapidly—less than one-fifth as many species in the lichen zone as in the birch zone.

Most mites have but few enemies outside of their predatory relatives; some hymenopterous parasites have been bred from ticks, and chrysopid, cecidomyiid, and coniopterygid larvæ sometimes attack red spiders. There are various cases of protective resemblance, especially among the immature forms. No examples of mimicry, I think, are known, but there are cases of structural convergence, due to habitat.

A great many mites are more or less injurious to the property of man. Five, at least, can be ranked as pests of great importance, namely, the cattle tick, the "moubata" bug, the sheep scab, the red spider, and the pear-leaf blister mite.

The classification of mites has, in recent years, been developed to a considerable degree. They are usually considered to be an order, including about 30 natural groups. An excellent historical review of the classification of acarians has been presented by Trouessart.[1] The value of these natural groups of mites has been variously estimated by different authors as tribes, subfamilies, and families. Linnæus placed all the mites known to him in the genus *Acarus*. In 1796 Latreille, in his "Precis," established the group "Acephales," which in 1806 he charged to "Aceres" for the mites. He divided it into four families, as follows:

Acaridæ (*Trombidium*, *Erythraeus*, *Carpais*, *Oribata*, *Acarus*, *Tyroglyphus*).
Riciniæ (*Sarcoptes*, *Cheyletus*, *Smaris*, *Bdella*, *Argas*, *Ixodes*, *Uropoda*).
Hydrachnellidæ (*Eylais*, *Hydrachna*, *Limnochares*).
Microphthira (*Caris*, *Leptus*, *Astoma*, all six-legged mites).

In 1816 von Heyden published a synopsis of his proposed classification, which in its completed form was never issued. A number of his genera are without species and so are unknown. He arranged the mites in four groups according to the number of legs and presence or absence of eyes.

In 1834 Dugès gave the first real classification of the acarians; he had seven families similar to the groups used to-day. They were Trombidiei, Hydrachnei, Gamasei, Ixodei, Acarei (*Sarcoptes*), Bdellei, and Oribatei. These families were based on the shape of the palpi, a character which, in general, is very useful, but which presents exceptions in almost every group. Thus the genus *Argas* was by Dugès placed in the Gamasei. He used the genus *Acarus* for what is now *Tyroglyphus*.

Koch, in general, followed Dugès, but made many new genera, often heterogeneous, and poorly characterized.

---

[1] Revue des Sciences naturelles de l'Ouest, 1891, p. 289–308; 1892, p. 21–56.

Kramer in 1877 originated an ingenious scheme, which has been extended by Canestrini, whereby the mites are arranged according to the position of the opening of the tracheal system. By this method there are six main divisions of the Acarina. Canestrini's classification is as follows:

Astigmata: Vermiformia and Sarcoptina.
Hydracarina: Water mites.
Prostigmata: The Trombidioidea and Eupodoidea of this paper.
Cryptostigmata: The oribatid mites.
Metastigmata: The ticks.
Mesostigmata: The Gamasoidea of this paper.

Trouessart has modified this scheme somewhat. He divides the mites into two orders, Acarina and Vermiformia; the latter group again into Octopoda (Demodicidæ) and Tetrapoda (Eriophyidæ). The true Acarina he divides into three suborders, the Prostigmata (including the Hydracarina of Canestrini), the Metastigmata (including the Mesostigmata and Cryptostigmata of Canestrini), and the Astigmata (including only the Sarcoptina). In the writer's opinion the Oribatidæ and Tyroglyphidæ are more closely related than indicated in either of these classifications.

The classification of Reuter (1909) does not differ greatly from that here adopted; the Oribatidæ and Sarcoptoidea are united into one group, the Sarcoptiformes. The Trombidioidea includes the Tarsonemidæ, while the Gamasoidea and Ixodoidea are united into the Gamasiformes.

Lahille proposed to use three suborders in the Acari, Stylocerata for the Prostigmata (except Bdellidæ), Arpagostoma for the ticks, and Chelicerata for all other groups. The fact that Lahille devoted his attention almost wholly to the ticks explains the classification.

In 1906, Oudemans arranged the mites in four subclasses, viz: Xemiostigmata for the Eriophyidæ, Lipostigmata for the Demodicidæ, Octostigmata for the Oribatoidea, and Distigmata for all the others. The Distigmata he divided into five orders for known forms, and another for supposed forms to connect two of the other groups.

Thor has arranged the Acarina in four subclasses, Vermiformia, Sarcoptina, Metastigmata and Prostigmata. The water mites are placed in the Prostigmata, and the Gamasidæ, Ixodidæ, and Oribatidæ in the Metastigmata.

Oudemans has proposed divisions of the Prostigmata with unwieldy names. The Eleutherengona for most of the group except Trombidiidæ and Rhyncholophidæ, and the water mites, which he calls Parasitengona; the Halacaridæ form the Pleuromerengona. The Parasitengona he divides into Apobolostigmata for the Rhyncholophidæ, and Eugonostigmata for the remainder; this latter is again divided into Phanerostigmata for the Trombidiidæ, and some parts of the Hydrachnidæ, and Calyptostigmata for the other forms.

Recently Ewing has proposed new names for various groups. The Prostigmata are divided into Hydracarina (water mites), Adactylognatha (Eupodoidea), and Dactylognatha for remaining families. The Parasitoidea and Oribatoidea are united under Peritremata; the Heterotracheata include the Heterostigmata (Tarsonemidæ), Ginglylosoma (Hoploderma), and Scleroderma (Oribatidæ); the sarcoptid and tyroglyphid mites are classed in Atracheata, and the Eriophyidæ in the Tetrapoda.

In the arrangement used below, the main divisions are about the same as in several recent classifications, although based largely on other characters. These characters will be found defined under the various families; and although there are exceptions to the tables they are not prominent, and to have provided for them would heavily encumber the synopses. The characters used in defining genera and higher groups vary greatly according to the group. In some cases genera are based on very minute structures, which in other families are of no value. In several groups the habitat is

the best clue to the systematic position. About 650 species are known from this country, where there are doubtless 2,000 or more, so that the student must not be surprised to find forms that do not fit into tables. Several of the families are not natural, and future study will greatly modify existing systems.

I have not made many new genera in the American mites. I believe in keeping genera as broad as possible. Division of a genus should be made only on grounds of convenience or those of zoological necessity. Because a group of species in a genus differs from the other forms by some structural character there is not, I think, sufficient reason for a new genus. But whenever a species, or group of species, differs from the others by several disassociated points of structure, together with differences in life history or habits, then a new genus is advisable. However, in using an accepted classification it is sometimes not easy to place a new form without either making a new genus or modifying the characters of existing genera. The history of acarology warrants the student in using much caution in the creation of new genera, or higher groups.

In regard to the nomenclature I have in general adopted that in common use in Europe. A number of changes have been made from the names used in the first edition of this work, several of which were then evident, but one dislikes to hasten in the use of proposed changes until it is seen that it will be accepted by the majority of workers in the group. A number of these changes were foreseen by Gervais in 1845, and had he been more generally followed the nomenclature would not present so many synonyms. Dr. Oudemans, an able Dutch acarologist, has adopted many other changes; but these involve principles of nomenclature not generally accepted by naturalists, and so are not recommended at present, and lately Dr. Oudemans has apparently abandoned some of them.

To the ordinary observer of nature mites do not exist. He may walk abroad and see birds and insects about him on every side; occasionally he may notice a tick or a harvest mite; yet a little careful searching would reveal a world of these tiny creatures at his feet. Among the fallen leaves of the forest, in the moss or lichens, under stones and loose bark, in fungi, in the loose upper surface of the soil, in the galls of plants, in the streams and ponds, and even in the depths of the sea there are mites innumerable. Hidden is this world of mites to the general naturalist as completely as though it were in another planet.

Although Müller early described many water mites, and Hermann (1804) and von Heyden (1816) had gathered a few, this world of mites was practically unknown until discovered by C. L. Koch about 1840. Since then a number of naturalists have partially explored its shores, and sometimes penetrated into the interior. Now there are more than a score of persons who seriously study acarology, as many more who devote themselves to the water mites, and others study the ticks, since these have been shown to be vectors of certain diseases.

SYNOPSIS OF SUPERFAMILIES.

1. Abdomen annulate, prolonged behind; very minute forms; often with but four legs.....DEMODICOIDEA.
   Abdomen not annulate nor prolonged behind; always with eight legs..... 2
2. With a distinct spiracle upon a stigmal plate on each side of the body (usually below) above the third or fourth coxæ or a little behind; palpi free; skin often coriaceous or leathery; tarsi often with a sucker..... 3
   No such distinct spiracle in a stigmal plate on this part of body..... 4
3. Hypostome large, furnished below with many recurved teeth; venter with furrows; skin leathery; large forms, usually parasitic.....IXODOIDEA.
   Hypostome small, without teeth; venter without furrows; body often with coriaceous shields, posterior margin never crenulate; no eyes....PARASITOIDEA.

4. Body usually coriaceous, with few hairs; with a specialized seta arising from a pore near each posterior corner of the cephalothorax; no eyes; mouth parts and palpi very small; ventral openings of the abdomen large; coxæ all close together; never parasitic; tarsi never with a sucker.....ORIBATOIDEA.
   Body softer, without such specialized seta..... 5
5. Living in water.....HYDRACHNOIDEA.
   Not living in water..... 6
6. Palpi small, three-jointed, adhering for some distance to the lip; ventral suckers at genital opening or near anal opening usually present; no eyes; tarsi often end in suckers; beneath the skin on the venter are seen rodlike epimera that support the legs; body often entire; adult frequently parasitic.....SARCOPTOIDEA.
   Palpi usually of four or five joints, free; rarely with ventral suckers near genital or anal openings; eyes often present; tarsi never end in suckers; body usually divided into cephalothorax and abdomen; rodlike epimera rarely visible; adults rarely parasitic..... 7
7. Last joint of palpi never forms a "thumb" to the preceding joint; palpi simple, or rarely formed to hold prey; body with but few hairs..EUPODOIDEA.
   Last joint of palpi forms a thumb to the preceding, which ends in a claw (a few exceptions); body often with many hairs.....TROMBIDIOIDEA.

SYNOPSIS OF FAMILIES.

DEMODICOIDEA.

With but four legs, of five joints each; living on plants, often in galls..ERIOPHYIDÆ.
With eight legs, of three joints each; living in skin of mammals.....DEMODICIDÆ.

SARCOPTOIDEA.

1. With tracheæ; no ventral suckers; legs ending in claws; body divided into cephalothorax and abdomen; the female with a clavate hair between legs I and II; not parasitic on birds or mammals.....TARSONEMIDÆ.
   Without tracheæ; no such clavate hair..... 2
2. Genital suckers usually present; not parasitic on birds or mammals; skin usually without fine parallel lines..... 3
   Genital suckers absent; parasitic on birds or mammals; skin with fine parallel lines..... 4
3. Legs short, without clavate hair on tarsi I and II; living on insects..CANESTRINIIDÆ.
   Legs longer, with clavate hair on tarsi I and II; not parasitic (except on bees).....TYROGLYPHIDÆ.
4. Possessing some specially developed apparatus for clinging to hairs of mammals.....LISTROPHORIDÆ.
   Without such apparatus..... 5
5. Living on plumage of birds.....ANALGESIDÆ.
   Not on plumage of birds, but on living tissues..... 6
6. Vulva longitudinal; in skin and cellular tissue of birds.....CYTOLEICHIDÆ.
   Vulva transverse; in skin of mammals and birds.....SARCOPTIDÆ.

PARASITOIDEA.

1. Palpi with the last joint enlarged; a spiracle situate above coxa III..HOLOTHYRIDÆ.
   Palpi not enlarged at tip; spiracles situate behind coxa III..... 2
2. Genital aperture near the anus; mouth parts retractile within a large buccal cavity, which is situated in an anterior part of the body separated by a suture from the rest of the body.....SPELÆORHYNCHIDÆ.
   Genital aperture not or scarcely behind the hind coxæ; no anterior part of body separated by a suture.....PARASITIDÆ.

ORIBATOIDEA.

1. No division between cephalothorax and abdomen.....LABIDOSTOMMATIDÆ.
   A suture between cephalothorax and abdomen..... 2
2. Cephalothorax movably attached to the abdomen; palpi four-jointed. HOPLODERMIDÆ.
   Cephalothorax not movable: palpi five-jointed.....ORIBATIDÆ.

Ixodoidea.

1. No scutum; no ventral shield; mouth parts of adult not prominent from above; no pulvillus to tarsus in adults.....ARGASIDÆ.
   Scutum present; sometimes ventral shields; mouth parts of adult prominent from above; pulvillus to tarsus of adults.....IXODIDÆ.

Trombidioidea.

1. Legs I and II with processes bearing spines; skin with several shields; coxæ contiguous.....CÆCULIDÆ.
   Legs I and II without such processes; few, if any, shields..... 2
2. Mandibles chelate or uncinate, that is a basal rather thickened part, with a claw near its tip..... 3
   Mandibles stylate (needlelike), and retractile; coxæ in two groups..... 4
3. Tarsal joint of leg I usually enlarged; usually a *crista metopica* on cephalothorax; coxæ in widely separate groups.....TROMBIDIIDÆ.
   Tarsal joint of leg I not enlarged, often long; no *crista metopica;* coxæ usually in one group, contiguous.....ANYSTIDÆ.
4. Tarsi enlarged; usually a dorsal groove; adults free.....ERYTHRÆIDÆ.
   Tarsi not enlarged; no dorsal groove..... 5
5. Phytophagous, occurring on plants; often spinning threads; palpi simple; leg I never ending in long hairs; all legs with claws; bristles usually simple. TETRANYCHIDÆ.

   Predaceous or parasitic, often on birds or mice; palpi often enlarged at base and forming a forceps; claws often absent from one or more pairs of legs; often with pectinate bristles.....CHEYLETIDÆ.

Eupodoidea.

Palpi simple; mouth parts hidden by a hood; no apparent division of body, and no bristles above; last joint of leg I but little longer than preceding. CRYPTOGNATHIDÆ.

Palpi often geniculate, or else fitted for grasping prey; mandibles large and snoutlike; cephalothorax with four long bristles above, two in front, two behind; last joint of leg I longer than preceding joint, often twice as long. BDELLIDÆ.

Palpi never geniculate, not fitted for grasping prey; beak small; cephalothorax with bristles in different arrangement; last joint of leg I shorter or but little longer than preceding joint; eyes, when present, near posterior border. EUPODIDÆ.

Hydrachnoidea.

Mouth parts carried upon a distinct beak; no ventral suckers; living in the sea. HALACARIDÆ.

Mouth parts not carried upon a beak; usually suckers near the genital openings; usually in fresh water.....HYDRACHNIDÆ.

If one desires to use suborders, three of these may be recognized, as follows:

1. With a distinct spiracle on a stigmal plate on each side of body near the third or fourth coxa; palpi free; skin often coriaceous; tarsi often with sucker; rarely any distinct eyes.....MESOSTIGMATA.
   No such spiracles or stigmal plates..... 2
2. Palpi usually of four or five joints, free; rarely with ventral suckers near genital or anal apertures; eyes usually present; tarsi never end in suckers; body soft; adults rarely parasitic.....PROSTIGMATA.
   Palpi small, rarely more than three-jointed, often hardly visible; often with ventral suckers; never with eyes; body often hard, if soft then showing rod-like epimera to support legs, and often parasitic.....CRYPTOSTIGMATA.

The Mesostigmata includes the Ixodoidea and Parasitoidea. The Prostigmata includes the Eupodoidea, Trombidioidea, and Hydrachnoidea. The Cryptostigmata includes the Oribatoidea, Sarcoptoidea, and Demodicoidea.

Superfamily EUPODOIDEA.

Family EUPODIDÆ.

The Eupodidæ is a small family of small mites, several species of which are among our most common acarians. They are soft-bodied, delicate mites, with moderately long to very long legs. The body shows more or less distinctly the division into cephalothorax and abdomen; the former usually bears an eye each side; the latter carries a few simple hairs. The palpi are short and simple, four-jointed, and with only a few hairs. The mandibles are rather small, but distinctly chelate; in one genus they are very large. The legs are six or seven jointed and terminate in two simple claws, and often with a median plumose pulvillus. The venter (fig. 8) has the usual openings, but in *Notophallus* the anal aperture is on the dorsum of the abdomen. In this genus there are a pair of suckers each side of the genital opening, apparently used by the mite to hold to smooth surfaces. These mites can run rapidly, and *Eupodes* can make considerable leaps. Most of them occur on the ground, but some are found on the leaves of trees. Many are predacious and feed on various small insects or insect eggs. They seem to delight in cold, damp places, and can be found in winter still active among and under fallen leaves. They are among the most common acarians in high latitudes, and are also frequent in caves, both of this country and of Europe, where their simple and primitive structure is well suited to the conditions.

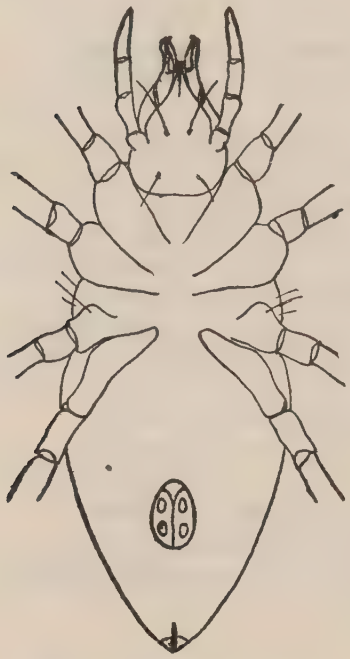


FIG. 8.—Venter of an eupodid. (Author's illustration.)

Their internal anatomy has been investigated by Nördenskiold, who finds that *Rhagidia* is among the most primitive of the Trombidioidea. The œsophagus, which opens near the tip of the labium or under lip, is very slender, and after passing through the large "brain," enters a very large stomach. From the upper part of this arises the intestine, which soon expands into a large colon, opening at the tip of the body. The eggs, as far as known, are laid upon the surface frequented by the adult. The larvæ resemble the parent, while the nymph differs only in size. There is no sexual dimorphism. Most of the common species vary a great deal in markings, the consequence being that Koch described each of the common European species under many different names, several having from 10 to 20 synonyms. Our forms have been collected only in the Eastern States. Their small size, soft body, and the rapidity of their motions makes it a very difficult matter to secure specimens in good condition for study; a toothpick dipped in glycerine is most useful for this purpose.

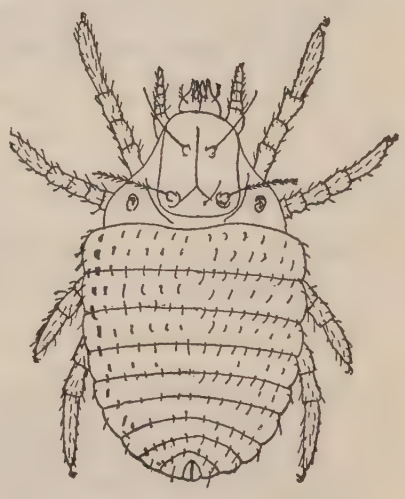


FIG. 9.—*Alichus roseus.* (Original.)

Two or three genera are sufficiently distinct from all others to form a subfamily, distinguished as follows:

1. Three suckers on each side of the genital aperture; a pair of submedian sensory hairs on the cephalothorax; abdomen more distinctly segmented.....ALICHINÆ.

But two suckers each side of the genital aperture; no submedian sensory hairs on the cephalothorax; abdomen only indistinctly segmented.....EUPODINÆ.

Of the Alichinae the two genera are distinguished as follows:

1. Mandibles long and slender; no eyes.....*Bimichaelia.*
   Mandibles stout; eyes present.....*Alichus.*

Alichus (fig. 9) and *Bimichaelia* (fig. 10) are pale or reddish minute species, with short legs. They occur in moss, or damp situations. *Bimichaelia* has been taken in Oregon. They are remarkable because of the distinct indications of abdominal segmentation. *Sebaia* is similar to *Bimichaelia*. Of the Eupodinæ there are many genera, the principal of which may be tabulated thus:

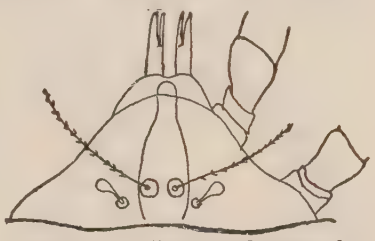


FIG. 10.—Cephalothorax of *Bimichaelia*. (Original.)

1. Legs extremely slender, front pair much more than twice as long as body; hind femora somewhat thickened.....*Linopodes.*
   Legs not much longer than body..... 2
2. Anal opening on the dorsum; last joint of palpus very short; patella of legs long; mandibles small.....*Notophallus.*
   Anal opening on venter..... 3
3. A rounded median tubercle on front margin of body; mandibles very large; hind femora not thickened.....*Rhagidia.*
   No such tubercle; mandibles smaller..... 4
4. Hind femora very much thickened, front legs much longer than others; last joint of the palpi slender.....*Eupodes.*
   Hind femora not or barely thickened..... 5
5. Last joint of palpus shorter than preceding; patella of legs elongate..... 6
   Last joint of palpus longer than preceding; patella of legs very short.....*Tydeus.*
6. Dorsum of cephalothorax with a median shield; color pale; no eye-spots; tarsi shorter than tibiæ.....*Ereynetes.*
   Dorsum of cephalothorax without a shield; color dark or reddish; an eye-spot each side; tarsi usually as long as tibiæ.....*Penthaleus.*

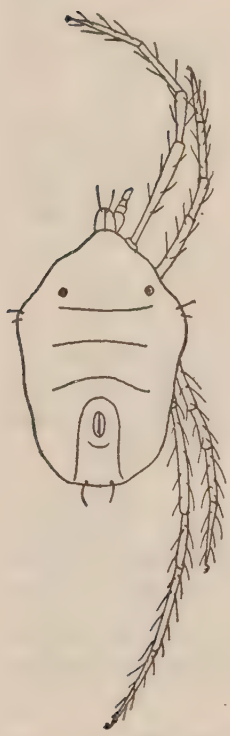


FIG. 11.—*Notophallus*, dorsal view. (Original.)

Our one species of *Linopodes* (fig. 12) is a very pretty pale yellowish or reddish mite, with some white marks; one on the back is in the form of a T. It is common on the ground under pieces of wood, bark, etc., that have lain there some time. The first pair of legs is used as feelers. Usually the mites walk slowly, but when disturbed run very rapidly. We have several species of *Eupodes* (fig. 15), all more or less marked with red. The common one, *E. variabilis* Banks, is found in the same places as *Linopodes*. Another species occurs on the seashore between tide marks, and one is found in caves.

The species of *Notophallus* (fig. 11) are blackish, with a red spot above, and red legs. They occur in damp fields, under stones, or in moss. Species of *Notophallus* have been found to be injurious to young plants, the mites sucking the leaves, and frequently causing the death of the tiny plants; one form is very injurious in the Southwest. Species of *Penthaleus* have a similar habit, and one in South Africa is known as the "earth flea." Several species of *Tydeus* (fig. 14) are known from the United States. *T. gloveri* Ashmead occurs on orange leaves in Florida, and feeds on the young and eggs of scale insects (*Lepidosaphes* spp.). It is pale reddish or yellowish in color and has a subpyriform body, with rather short legs. Moniez has described a species of *Tydeus* (*T. molestus* Moniez) as attacking man, much on the "red-bug" style. *Rhagidia* is a remarkable genus. The species are pale or whitish in color, and occur under damp, fallen leaves and on moist soil. It is much larger than the other species of this family, and sometimes fully 1 mm. long. Its structure is in many ways very similar to that of certain Solpugida and suggested to Thorell

its generic name, which is a diminutive of *Rhax*, a genus of Solpugida. It is probable that it is the most primitive of all existing mites, and points to the close relationship of the Acarina to the Solpugida. Our common species, *R. pallida* Banks (fig. 13), is found throughout the country, but more commonly in the north. Other species are found in Europe, Japan, Kerguelen, Chile, and the arctic regions.

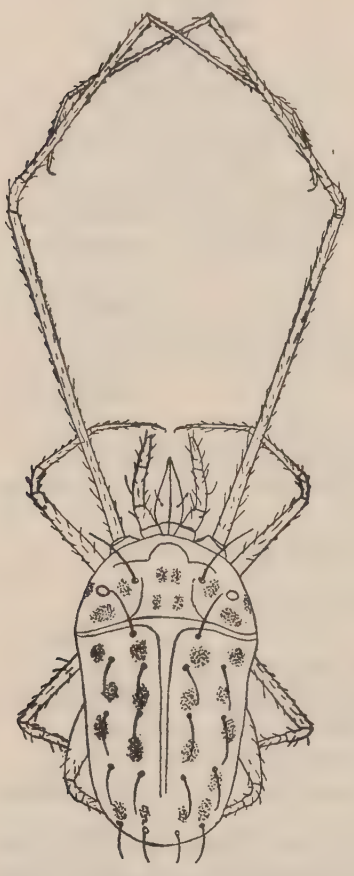


FIG. 12.—*Linopodes antennaepes.* (Author's illustration.)

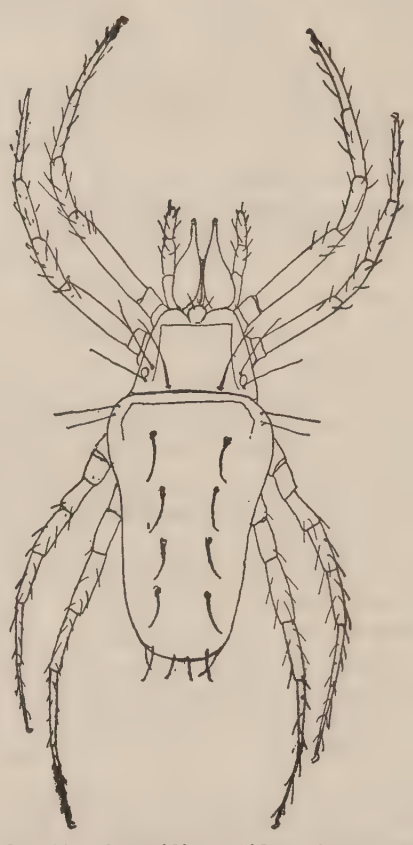


FIG. 13.—*Rhagidia pallida.* (Author's illustration.)

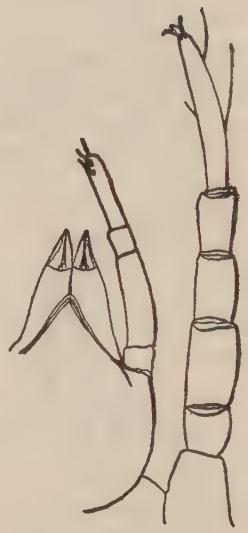


FIG. 14.—*Tydeus:* Beak and leg I, from below. (Author's illustration.)

A European mite of this family, *Ereynetes limaceum* Koch, sometimes occurs upon certain species of slugs (*Limax*), and sometimes attached to a fly (*Sarcophaga*). What appears to be the *Ereynetes concolor* Hald. (fig. 16) occurs in our country on both slugs and snails, and runs very rapidly in an irregular manner over the animal, retreating (perhaps to feed) into the respiratory chamber of the snail. The tarsi terminate

FIG. 15.—*Eupodes:* Legs I and IV. (Original.)

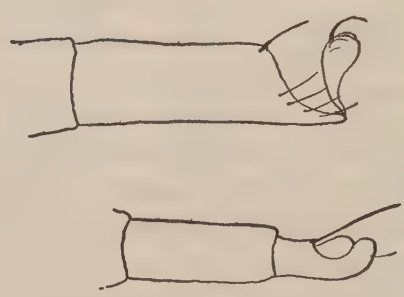


FIG. 16.—*Erynetes concolor:* Tarsus and palpus. (Original.)

obliquely and have a large double pad at tip, with two slender claws. Two genera, allied to *Alichus*, are saltatorial; one, *Nanorchestes*, occurs in the crevices of rocks on the French coast; the other, *Speleorchestes*, is found in ant and termite nests, one species in Sweden, the other in South Africa; the femora are not enlarged, but the hind coxæ are highly developed.

Recently Thor has made a new family, Teneriffiidæ, for two new genera related to Eupodidæ and Anystidæ, but having some characters of Trombidiidæ. The palpi end in one large and two small claws, one of the latter in the position of the "thumb" of the Trombidiidæ. The coxæ are large, close together, and radiate; the ventral apertures are large, elongate and approximate; the basal joints of the palpi are enlarged. The mandibles are chelate, and the tarsi end in two claws; there is no crista, nor shields on the dorsum. They appear to be most closely related to the Eupodidæ. *Teneriffia*[1] (fig. 17) comes from the island of Teneriffe, and *Parateneriffia* from Paraguay. Little is known about their habits, except that they are not parasitic.

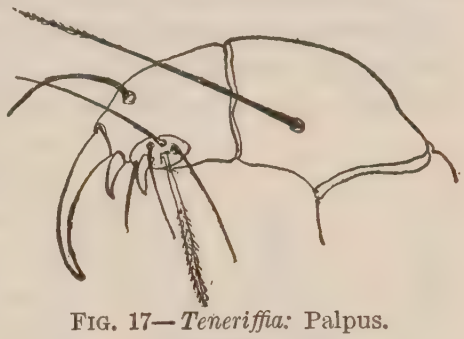


FIG. 17—*Teneriffia:* Palpus. (Original.)

FAMILY CRYPTOGNATHIDÆ.

This family is based on a tiny red mite found in Europe, and described in 1879 by Kramer as *Cryptognathus lagena* (fig. 18). The body shows no division into cephalothorax and abdomen; the coxæ are radiately arranged close together; the genital aperture is near the tip of the body, and the anus is at the tip; the palpi are long and simple; the legs (subequal in size and length) are simple, and end in two claws; the mandibles are chelate, but weak; the surface of the body is divided into many tiny, irregular areas (somewhat as in *Raphignathus*), and there are two eyespots on each side. But the most peculiar point is a large, hyaline hood in front of the body, over and partly surrounding the mouth parts. The mite was found in moss, and nothing is known of its habits.

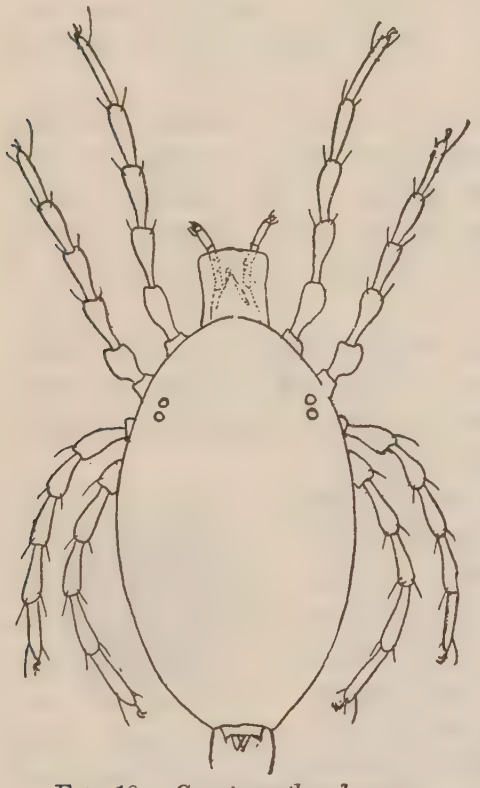


FIG. 18.—*Cryptognathus lagena.* (Original.)

FAMILY BDELLIDÆ.

The members of this family are known as "snout mites," from the appearance of the beak or rostrum. The body shows distinctly the division into cephalothorax and abdomen, the two hind pairs of legs apparently arising from the latter. The cephalothorax is subtriangular, with a few long bristles above and usually one or two eyes on each side, commonly near the posterior corner. The mandibles are large, slender, tapering, more or less united along the median line, and together form a prominent cone in front. They are chelate in the typical genus, but in some of the other genera end in one claw. The palpi arise apparently from near the base of the mandibles, but really from a part of the body below them. They are either three or five jointed, the second joint being the longest. In some forms they are provided with spinelike bristles, but usually with fine hairs, the terminal ones often of great length. The palpi are frequently elbowed between the second and third joints. The abdomen is usually broadest at the shoulders and tapering, but rounded behind; it bears only a few short hairs or bristles. The venter (fig. 19) has the usual two apertures near the

[1] Strand's substitution of *Teneriffiola* is not needed, since Becker's genus was spelled *Teneriffa.*

posterior part, the genital usually the larger. The legs are quite long and slender, with a few scattered small hairs, and terminate in two claws with a median hairy brush beneath them. The hind coxæ are often well separated from the anterior pairs, but in *Bdella* they are approximate.

The internal anatomy has been studied by both Karpelles and Michael. It is peculiar in several respects. There is a large sac or diverticulum connected to the œsophagus above, which Michael has termed the "receptaculum cibi," and he believes its purpose is to store the food for a short time. The ventriculus ends blindly, there being no communication to the anus. There are three pairs of glands in the anterior part of the body, besides one large median gland. One pair opens at the base of the mandibles; their function is unknown. Two pairs open into a common duct which leads to the mouth; they are probably salivary glands. The supraœsophageal and subœsophageal ganglia are more distinctly separated than in other mites that have been examined. The pharyngeal nerve (which in other mites is single) in *Bdella* is split in two parts. The male organs are remarkable for possessing two single and one pair of accessory glands, whose function is little understood. In the female there is but one oviduct.

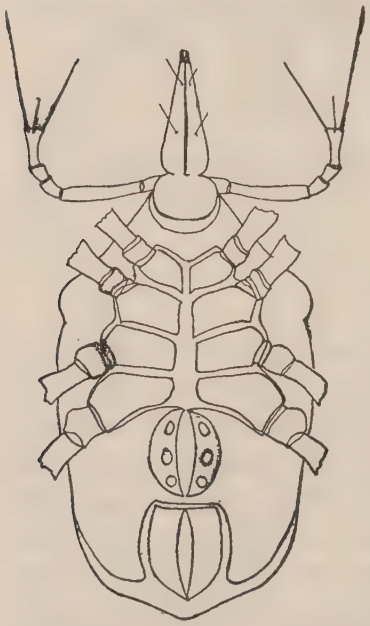


FIG. 19.—Venter of a *Bdella*. (Author's illustration.)

Trägardh has figured the egg of *B. arctica* Thor. (fig. 20); it is nearly spherical, and with a number of long spines scattered over the surface. The larva and nymph have much resemblance to the adult. They are never parasitic, and there is no sexual dimorphism, but the life history is not fully known.

Several species of Bdellidæ are common in the far north and have extended southward along the coasts of both continents, and so have received a number of names. Most of the forms seem to like the cold, and often occur in damp situations; they are among the most common mites of the Arctic regions, while but few are known from the Tropics. The species are usually red in color, but some are blackish. They are predaceous in habit and wander about in search of food—any small creature they can find. The palpi serve as tactile organs in most genera, but in *Cunaxa* (fig. 23) they are used to capture and hold their prey. These mites can run quite fast, and move backward as well as forward. Five genera have been recognized in this country, and one more (*Scirula*) is known in Europe. These may be separated by the following tables:

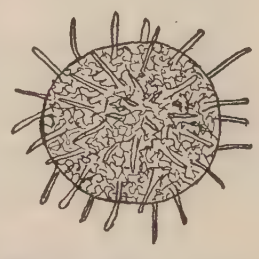


FIG. 20.—Egg of *Bdella*. (Author's illustration.)

1. Mandibles chelate; two eyes each side; palpi geniculate, and ending bluntly in two or more long bristles 2
   Mandibles ending in one claw; no eyes, or only one each side; palpi not geniculate, and ending in a claw 4
2. A median eye on front of the cephalothorax; tips of tarsi without plumose bristles ..... *Cyta.*
   No median eye; tips of tarsi with one or two plumose hairs each side 3
3. Last joint of palpus short, widened at tip ..... *Bdella.*
   Last joint of palpus long, cylindrical ..... *Scirus.*
4. With eyes; palpus of three joints, and without spinelike bristles ..... *Eupalus.*
   Without eyes; palpus of more than three joints 5
5. Palpi long, with spinelike bristles ..... *Cunaxa.*
   Palpi short, thick, no spinelike bristles ..... *Scirula.*

Trouessart has separated the group of *Cunaxa* from the Bdellidæ and placed them as a family of Trombidioidea; this does not appear natural to me. Of *Cunaxa* three species have been described in the United States; they live in damp places and are very active. This genus (*Cunaxa*) was formerly called *Scirus*, but the type of *Scirus* is very close to the true *Bdella*. Of *Bdella* we have a number of species, and some are

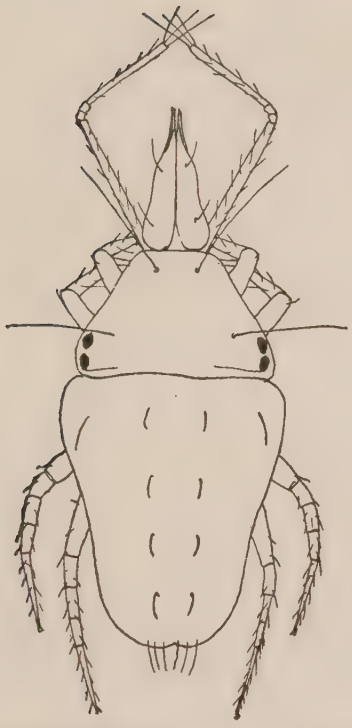


FIG. 21.—*Bdella peregrina*. (Author's illustration.)

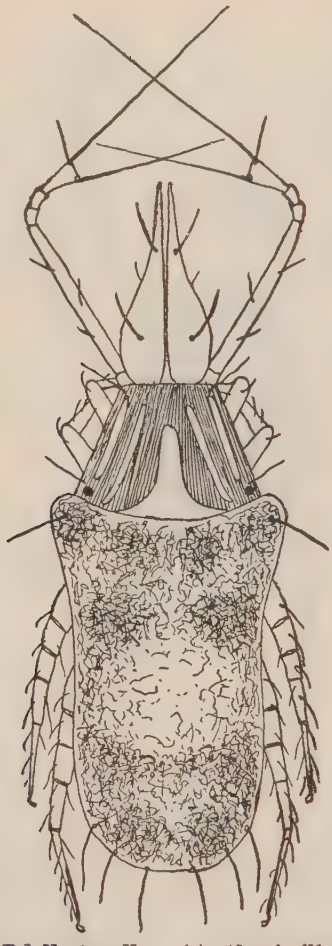


FIG. 22.—*Bdella tenella*. (Author's illustration.)

common. They usually inhabit moist places, moss, rotten bark, etc. One species (*B. marina* Packard) is common along the North Atlantic shore between tide marks. *B. cardinalis* Banks and *B. peregrina* Banks (fig. 21) are common on damp soil; *B. tenella* (fig. 22), under rotten bark; *B. utilis* Banks, with scale insects. Michael has recorded finding a species of *Bdella* on the web of a tube-weaving spider, *Amaurobius ferox* Blackw. The mites were not disturbed by the spider and evidently felt much at home. They doubtless fed on some of the small insects disdained by the spider. Ewing has found several species under the loose bark of trees in Illinois, where they feed on the tyroglyphids and Collembola. *Scirus* can be used for that section of *Bdella* which has the last joint of the palpi long and cylindrical; *Bdella*, for those with this joint short and widened at tip. *Molgus* is used by some authors for the long-palpi species with numerous bristles on the mandibles. Several of our species described in *Bdella* will thus belong to *Scirus*. The genus *Cyta* is very similar to *Bdella;* our one species (*C. americana* Banks) occurs in damp fields; it was formerly known as *Ammonia*, which name is not only later but also preoccupied. The genus *Pseudocheylus* of South America has the claw-tipped palpus of *Cunaxa* but with a very much shorter claw.

FIG. 23.—Mandibles and palpus of *Cunaxa*. (Author's illustration.)

Superfamily TROMBIDIOIDEA.

Family CHEYLETIDÆ.

The Cheyletidæ are a small family of tiny mites, differing considerably in habits and structure among themselves. The typical forms are distinguished by the enormous palpi attached to a distinct beak. The palpi are three to five jointed, and frequently have a minute movable tubercle or papilla near the tip on inner side, which in some forms is tipped with one or two pectinate bristles. This papilla is evidently homologous with the "thumb" of the Trombidiidæ. The beak is plainly separated from the body by a deep constriction, and in front has the circular mouth opening or camerostome, through which the mandibles may be extended or retracted. The body is usually oval; the skin soft, occasionally with chitinous plates, and in many forms finely striate. The division between the cephalothorax and abdomen is rarely present. The body bears a few hairs, sometimes in the form of scales. The legs are generally short, five-jointed, and usually end in two claws, with a bunch of hairs or a pectinate bristle between them. In some species the front legs terminate in bristles and appear to have a tactile function; in others the front legs are transformed into clasping organs. Sometimes there is an eye on each side of the cephalothorax, but it is not often distinct. The mandibles are commonly long and needlelike, fitted for piercing tissues; in one genus, however, they have two points, indicating their chelate origin. The female genital aperture is just in front of the anus, which is at the tip of the venter. The male aperture is behind the anus, and often near the middle of the dorsum. The penis is very prominent, long, slender, and curved, and is often found partially extruded. The internal anatomy of the Cheyletidæ has not been thoroughly examined. The digestive tube is simple and the stomach is provided with four large cæca. In one genus, *Harpyrynchus*, there is no anus; the food of this mite is of such a nature as to be completely digested. The respiratory system is perhaps more complete than that of other families. There are two large tracheal trunks starting from the beak and extending back to near the tip of the body, each emitting many smaller branches which ramify throughout the body. From some accounts it appears that the main trunks are composed of two or three separate tracheæ. These main trunks are connected to each other near their origins. The spiracles are at the sides of the beak, and in some cases there are two others near the median line. These spiracles are sometimes trumpet-shaped. The nervous system consists of a band around the œsophagus and 10 branches from it, 4 in front and 6 behind. Two of these branches go to the beak, others to the legs, and two to the posterior part of the body.

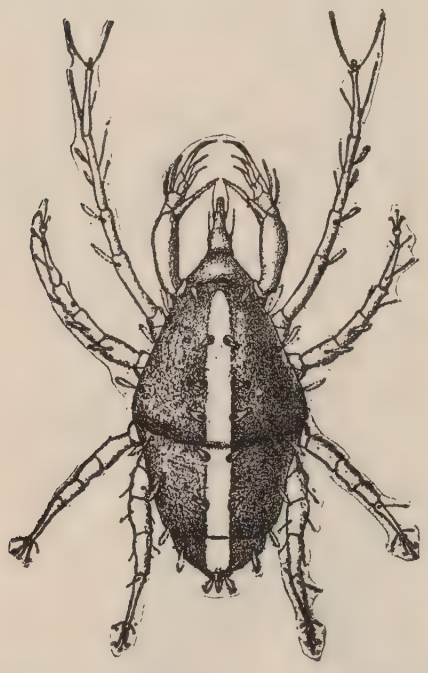


FIG. 24.—*Cheyletus* sp. (From Marlatt.)

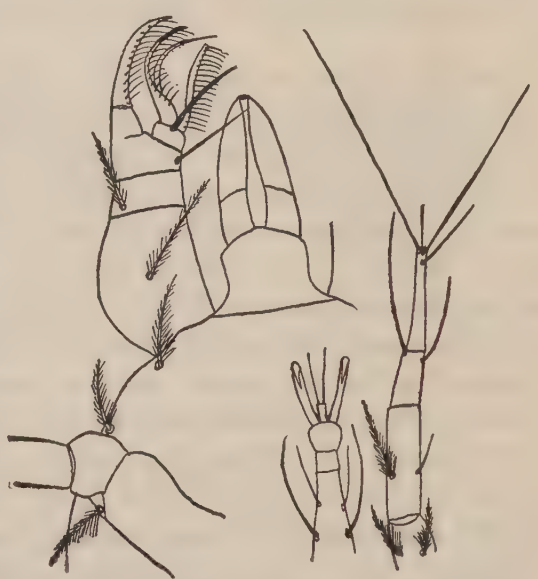


FIG. 25.—*Cheyletus pyriformis:* Beak and palpus, tip of leg I, and claws of leg II. (Author's illustration.)

But little is known of their habits. The free-living forms move slowly and are so small that they have not often been watched by naturalists. Most of them are pale-colored, unmarked, but a few have darker marks; some are clothed with ribbed, scalelike hairs. The eggs are deposited singly or in clusters, and by some species a web is spun over them, or at least a few threads to hold them in place. In a few species the mother remains to guard the cluster for some time. The larva, upon hatching, has much resemblance to the adult, but, of course, only six legs. The nymph looks still more like the parent, and there are but few differences between the sexes save that the male is smaller. Cheyletidæ feed on animal life, some being predaceous, others parasitic. A few may be said to belong to both groups, inasmuch as they occur upon certain animals only to prey upon the parasites of the host.

Only a few genera are known, and of these but six have been recorded from this country.

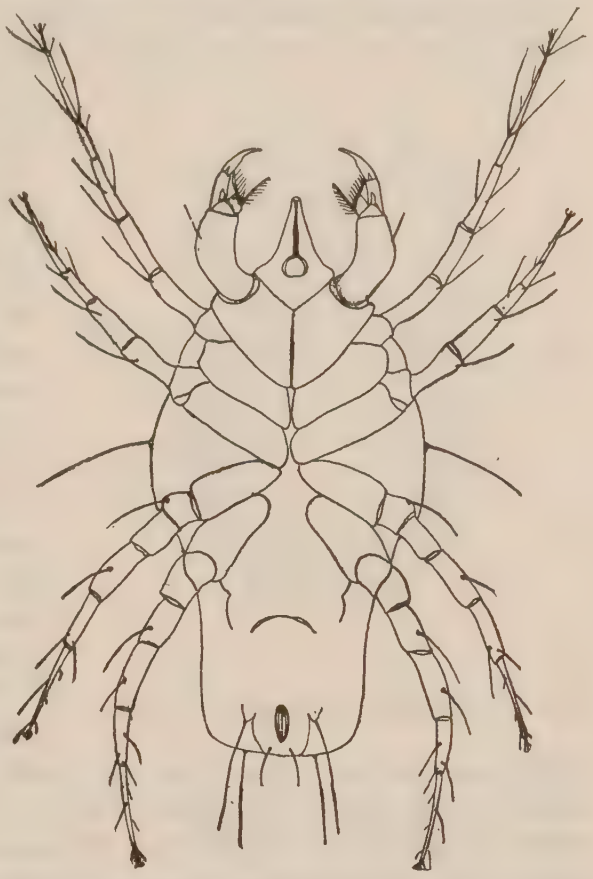


Fig. 26.—*Cheyletus audax*, from below. (Author's illustration.)

1. Leg I fitted to clasp hair, with one large curved claw; hind legs with one claw..... *Myobia.*
   Leg I not fitted to clasp hair; hind or front legs with two claws..... 2
2. Palpi curving toward each other to form a forceps..... 5
   Palpi not forming a forceps..... 3
3. Body elongate; palpi simple; a plumose or forked pulvillus to tarsi..... *Picobia.*
   Body short and broad..... 4
4. Hind legs with claws; palpi without recurrent hooks..... *Psorergates.*
   Hind legs without claws, very short and tipped with bristles; palpi with recurrent hooks..... *Harpyrynchus.*
5. Tarsus (or papilla) of palpus with only simple hairs, no combs; body short and broad..... *Cheyletiella.*
   Tarsus (or papilla) with pectinate bristles..... 6
6. Palpus with a comb..... 7
   Palpus without a comb; only the anterior dorsal shield present, which is acute behind; body elongate..... *Cheletoides.*
7. Palpus with but one comb..... 8
   Palpus with two combs..... 9
8. With two large dorsal shields, not far apart; body not very long..... *Acaropsis.*
   With but one (the anterior) shield; or a small one near tip of body; body elongate..... *Cheletopsis.*
9. With broad, scalelike or fan-shaped hairs; an eye spot each side..... *Cheletia.*
   Without such broad scalelike hairs; usually no eye spots..... *Cheyletus.*

Cheyletus (fig. 24) contains many species; a number have been found on the skins of birds, where they doubtless feed on the parasitic analgesid mites. They are very small (about 0.5 mm. in length), live freely, and prey upon other mites and small insects. They seize the prey with their big palpi, insert the mandibles, and suck it dry. Some have thought that there must be poison glands in the palpi, since the prey ceases movement very soon after capture. Two species, one of them *C. clavispinus* Banks, have been found attached, in adult condition, to Hemiptera of the genus *Aradus*. They are evidently not parasitic, but use the insect only for transportation. Another of our species, *C. pyriformis* Banks (fig. 25) was found feeding on a scale insect on grapevine, another on *Cicada* eggs, and a third, *C. audax* Banks (fig. 26) attacking

Tyroglyphids among cabbage seed. Several tropical species are found with scale insects, and doubtless feed on them.

Cheletia Haller differs only in having broad, scalelike hairs on the body and legs, making them very beautiful objects when seen under the microscope. Some of the species also feed on scale insects, and one such occurs in the West Indies. *Cheletoides* and *Cheletopsis* (fig. 28) are elongate mites that live within the quills of the feathers of birds. Some species have also been found outside the quills; doubtless all come outside at certain times, at least to breed. They are supposed to feed on the analgesid mites that occur with them in the quills, and to which they bear much resemblance.

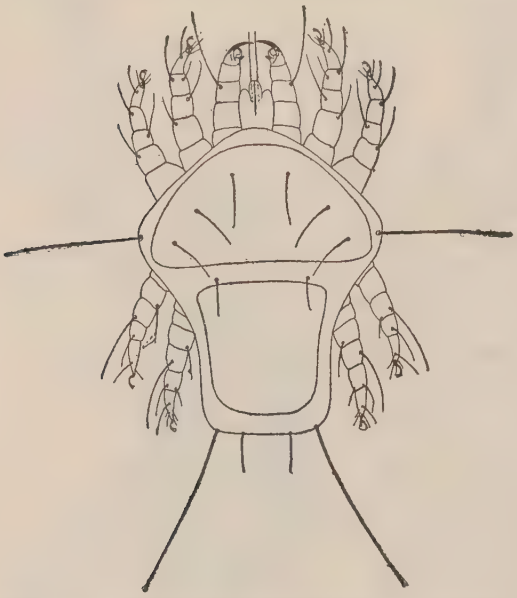


FIG. 27.—*Cheyletiella canadensis.* (Original.)

Dr. Oudemans, who has written a revision of the Cheyletinæ of the world, has described many new species from foreign countries. He adopted 17 genera, several of which are known from but one species. For *Cheyletus* he uses the spelling *Cheletes*.

For *Harpyrynchus* he proposes a new name, *Sarcoborus*, as there was an earlier *Harporynchus;* but the latter does not exactly preoccupy the acarian genus; moreover there is a *Sarcopterinus* Railliet 1893 which would be available. His genus *Cheletomorpha* differs from *Cheyletus* in the presence of an eye-spot each side on the dorsal shield, while *Cheletophanes* is a similar form with a peculiar sculpture to the posterior part of the body. *Cheletomimus* is about the same as *Cheyletia*, but the posterior dorsal shield is divided, and there are not so many scalelike hairs. *Cheletogenes* is also similar to *Cheyletia* but with roughened shields. *Chelenotus*, I have united to *Acaropsis*, and *Cheletosoma* to *Cheletopsis*.

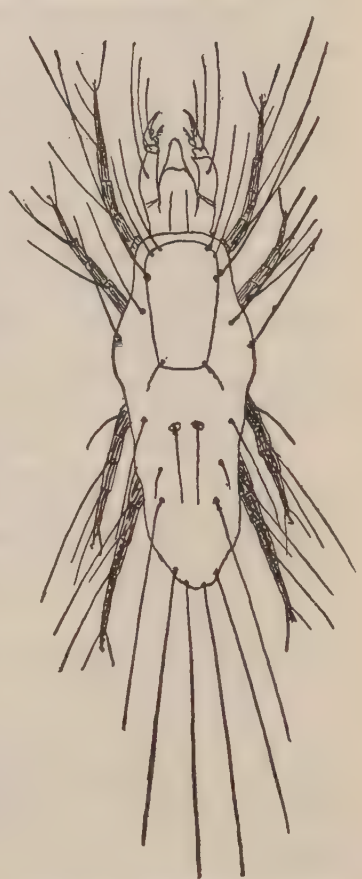


FIG. 28.—*Cheletopsis nörneri.* (Original.)

Cheyletiella (fig. 27) includes several species in which the palpi are not as large as in *Cheyletus*. They usually occur on birds, where they feed on the other mites present and have been called auxiliary parasites. One species, *C. parasitivorax* Mich., uses the rabbit's fur as a hunting forest, where it destroys the *Listrophorus* mites which occur on the hairs of the rabbit. One species (on a bluebird) has been recorded from this country. *Harpyrynchus* (formerly *Sarcopterus*) is represented by a few species that have a very short, broad body, with very short legs, the hind pairs ending in a bunch of bristles. They occur in the hair follicles of several birds, where they form tumors. The eggs are very large for the size of the mite. One species, *H. longipilus* Banks (figs. 29, 30) has been taken in the United States in a tumor under the wing of a crossbill. The genus *Psorergates* (fig. 31) was described by Tyrrell from Canada. It lives parasitically on the house mouse and field mouse, in cavities, or little cells, just beneath the surface of the skin. It has a nearly round body, with very short, stout legs, each ending in two stout claws. It has since been found in various parts of Europe, and was described by Michael under the name of *Goniomerus musculinus* Mich.

The genus *Myobia* (fig. 32) was based on a species from the head of the house mouse. All the legs are very short and thick, but the first pair are heavier than the others and

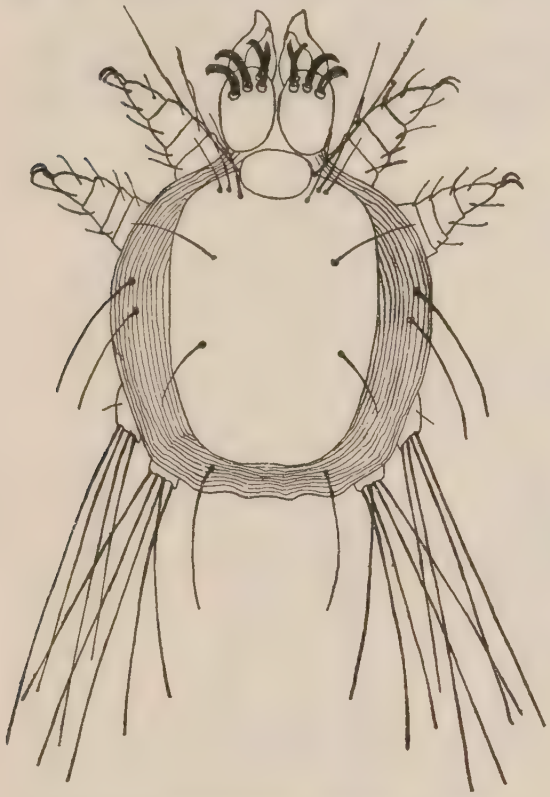


FIG. 29.—*Harpyrynchus longipilus:* Female. (Author's illustration.)

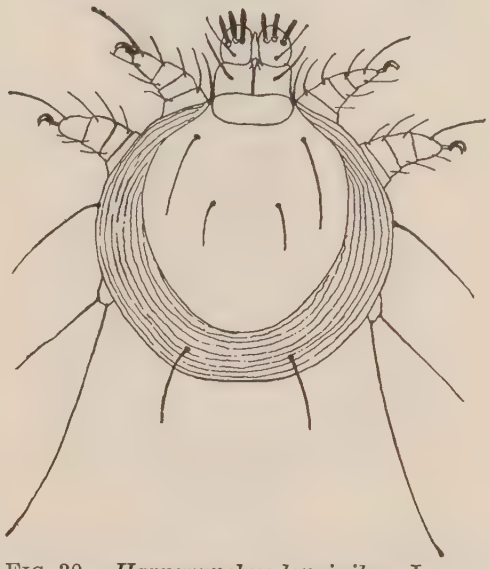


FIG. 30.—*Harpyrynchus longipilus:* Larva. (Author's illustration.)

transformed into an organ fitted to grasp the hair. The eggs are fastened to the hair of the mouse. The nymph differs considerably from the larva and adult in the structure

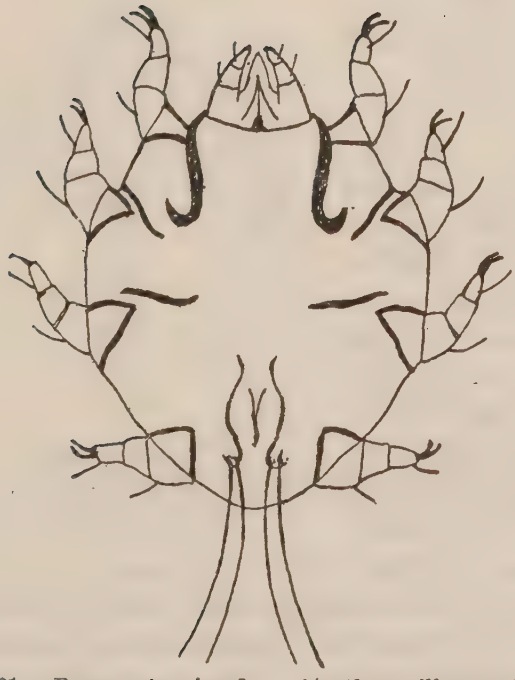


FIG. 31.—*Psorergates simplex.* (Author's illustration.)

FIG. 32.—*Myobia canadensis.* (Original.)

of legs and beak, the palpi being atrophied. In this stage it burrows into the hair follicles, feeds there, and transforms. It is not supposed to suck the blood, but to

feed on matter secreted by the skin of the host. Several other species are found on allied mammals, and one infests bats in Canada. Osborn has recorded the presence of *M. musculi* Schrank in this country.

Picobia (figs. 33, 34) has an elongate body provided with long bristles. They live in the quills of the feathers of various birds, coming out only for breeding and migration. One of these was recorded from Arizona by Hancock as *Picobia villosa*, which Trouessart states is the same as *P. bipectinatus* Heller of Europe. Trouessart also claims that this is not an adult mite, but that it is a stage (which he calls "syringobial") in the life of a *Cheyletiella*. *Syringophilus* (*Picobia*) is not a stage of *Cheyletus nörneri* Trouess., as held by Trouessart, but a very distinct form; indeed Nörner had described the male and egg of *Syringophilus*. The likeness between the two is a convergence due, as shown by Oudemans, to their common habitat, the interior of the quills of feathers, both being elongate and with short legs.

FIG. 33.—*Picobia helleri*. (Original.)

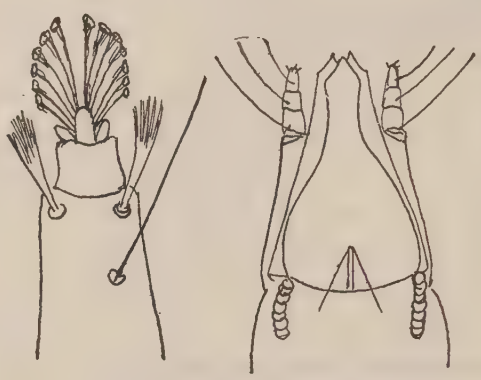


FIG. 34.—*Picobia helleri:* Tarsus and head. (Original.)

FAMILY ANYSTIDÆ.

There are few species of mites in this family, but one is very common and beneficial. Most of them are at once separated from all other Trombidioidea in that the coxæ are close together and arranged in a radiate manner. The body shows no complete division between cephalothorax and abdomen, although in the typical genus the division is often indicated just behind the third pair of legs. The body, which is usually short and broad, is provided with many stout bristles. In front on each side are one or two simple eyes. The mandibles are quite large and prominent, and taper to a point which is tipped by a curved claw. The palpi are prominent but slender; in *Tarsotomus* with a long "thumb," but in *Anystis* the last joint is terminal. The legs are large and long, gradually tapering and provided with many long hairs or bristles. They are six or seven jointed, and terminate in two or three claws. In some species the tarsus is divided into a number of small joints. On the venter (fig. 35) are genital and

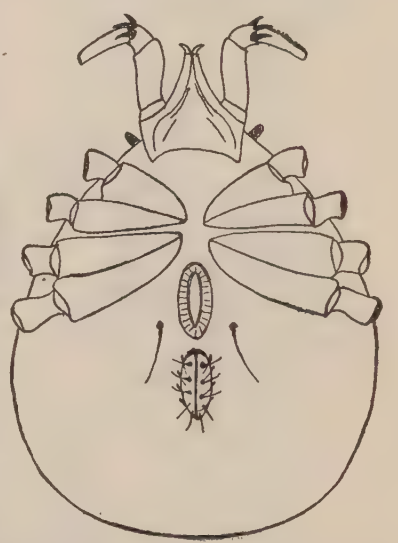


FIG. 35.—Venter of *Anystis*. (Author's illustration.)

anal openings, both quite elongate. The young resemble the adult, except in having but six legs. This family was formerly called Erythraeidæ but the generic name *Erythraeus* was first applied to mites of the family Rhyncholophidæ. *Erythacarus* Berlese is the same as *Tarsotomus*. There are several genera and subgenera, the more prominent of which are tabulated below:

1. Palpi without claw at tip, no visible "thumb"; body short and rounded; coxæ all approximated ..... *Anystis.*
   Palpi with a claw to last joint, not counting the "thumb"..... 2
2. Thumb of palpus very small, indistinct; tarsi all simple; parasitic on reptiles. 3
   Thumb of palpus very large, plain; tarsi often long, sometimes curved, or with false articulations; coxæ approximate; body elongate; free-living..... *Tarsotomus.*
3. Coxæ approximate; body broader than long..... *Gekobia.*
   Coxæ in two groups; body elongate ..... *Pterygosoma.*

FIG. 36.—*Tarsotomus spinatus.* (Author's illustration.)

Anystis and *Tarsotomus* are free and predaceous, feeding on any small insects or acari that they may come across. Their movements are excessively rapid and erratic, sometimes whirling about in a zigzag course like a particle of dust blown by the wind. In *Anystis* the body is triangular and the palpi are four-jointed. In *Tarsotomus* the body is more elongate, and the palpi five-jointed.

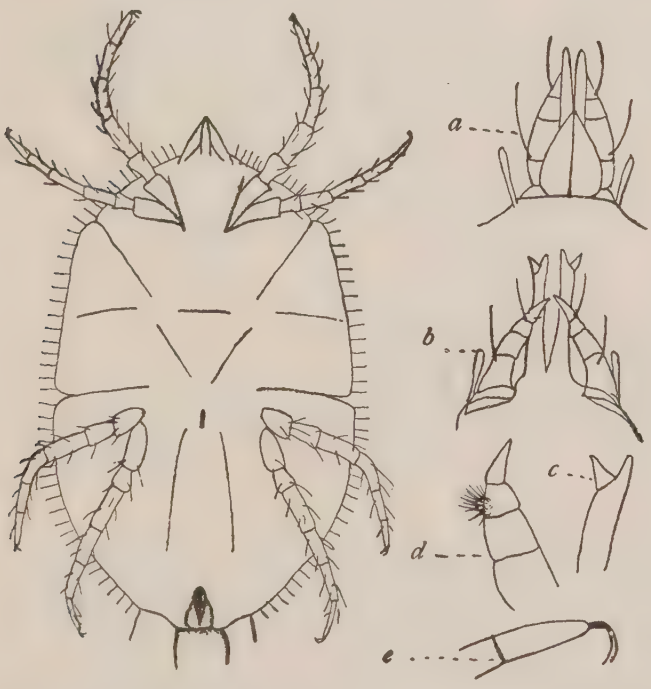


FIG. 37.—*Pterygosoma texana: a*, Beak above; *b*, below; *c*, tip of mandibles; *d*, palpus; *e*, tarsus with claws. (Author's illustration.)

Our one species of *Anystis*, *A. agilis* Banks, is commonly found running over the leaves of herbs and shrubs in the search for prey. It is red in color. I have seen it feed onaphides, on small caterpillars, and on the young larvæ of the currant sawfly. The young before transformation spins a white silken web on a leaf or in a crevice of bark, and beneath it changes to the adult form.

Species of *Tarsotomus* (fig. 36) are known to occur about houses, but most of them live on trees. They are usually red in color, but some are marked with white spots and stripes. They are not very common in our country, only two species having been described. *Gekobia* is found attached to various reptiles, especially lizards; three species are known from Europe. *Pterygosoma* is much more elongate than *Gekobia;* one species, *P. texana* Banks (fig. 37), occurs on a lizard, *Sceloporus floridanus*, in the Southern States; others occur in Africa and Italy.

The mandibles have a peculiar structure; they consist of a stout rod with a short, acute, stout spur near the tip. They are supposed to suck blood from the lizards; nothing is known of their earlier stages.

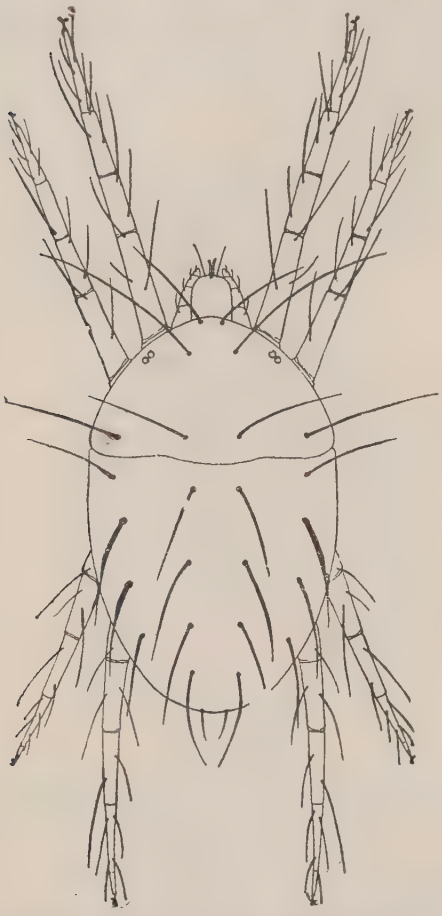


FIG. 38.—*Tetranychus bimaculatui.* (Author's illustration.)

FAMILY TETRANYCHIDÆ.

The members of this family, commonly known as "red spiders," have for many years attracted attention, owing to their ravages to cultivated plants. Since many of the species can spin a silken thread they have also been called "spinning mites." Their structure presents few remarkable characters. The body is oval or elliptical, provided with a few, mostly long simple hairs, arranged in four rows. The cephalothorax (fig. 40) is separated from the abdomen by a furrow, and bears on each side one or two simple eyes. The palpi are short, the penultimate joint ending in a claw. The last is "thumblike" and bears one or more appendages called "fingers." In some species the palpus of the male has a short curved spine at the tip on the upper side of the third joint. The mandibles (fig. 39) have their basal joints united in a plate; the apical joint, being very long and flexible, is fitted for piercing plant tissues, and is known as the stylet. The legs (fig. 41) are moderately slender, the first pair the longest, with scattered hairs, and ending in one or two claws. In many species of *Tetranychus* the claw (fig. 43) is split into four pieces, whence the name. On the under side of the abdomen are two simple openings, the basal the genital (fig. 42), the other the

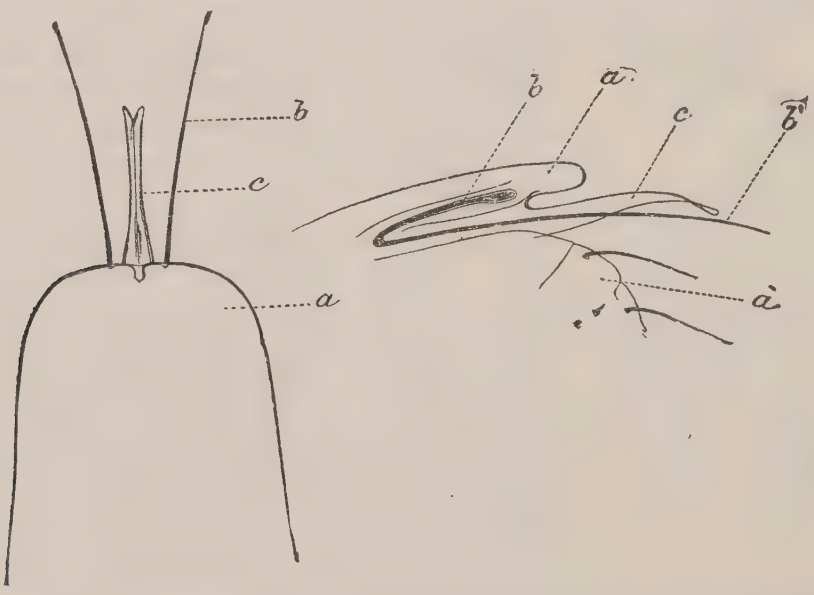


FIG. 39.—*Tetranychus*, mandibular plate, dorsal and lateral views: *a*, Plate; *b*, stylet; *c*, spina; *d*, palpus. (Author's illustration.)

anal. The former in the female is usually transverse. In the male it is longitudinal and often shows the slender curved penis. Ewing has used the shape of the penis in the distinction of species.

Parthenogenesis has been claimed for several species of *Tetranychus*.

Several authors (Megnin, Kramer, Trägardh) have kept the Tetranychidæ separate from the Raphignathidæ, since in the latter family the abdomen is more or less distinctly divided into segments, but this seems hardly advisable, considering the variation and indistinctness of the segmentation. The more prominent genera are distinguished in the following table:

1. Tarsi (at least tarsus I) much shorter than the preceding joint; at least leg I as long as, or longer than body..... 2
   Tarsi as long as preceding joint; leg I rarely as long as body. 5
2. Front margin of cephalothorax with a thin four-lobed or cleft plate; body with scalelike hairs....*Bryobia*.
   No such plate on front of body..... 3
3. Body with simple hairs; prostigma in a horn each side at base of mandibles.....*Tetranobia*.
   Body with spines or stiff serrate bristles; prostigma not in a horn..... 4
4. Tarsi I enlarged a little near tip; palpi stout.....*Tetranychina*.
   Tarsi I tapering to tip; palpi small and slender; coxæ close together. *Neophyllobius*.
5. Dorsal surface divided into many small areas; claws two, very large..*Raphignathus*.
   Dorsal surface not so divided..... 6

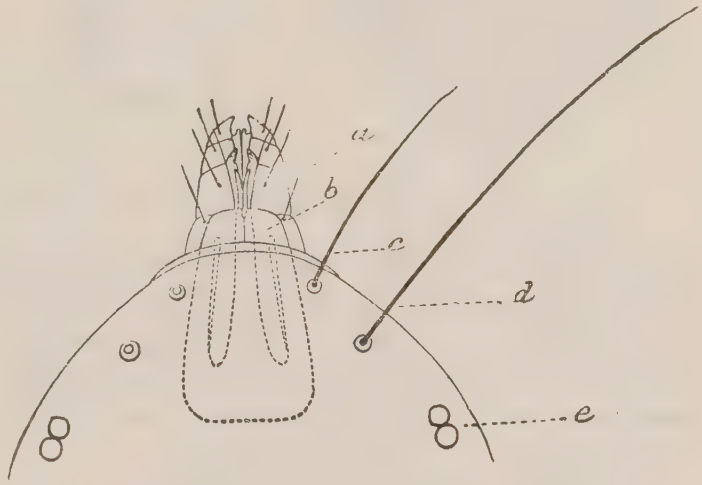


FIG. 40.—*Tetranychus*, cephalothorax from above: *a*, Palpus; *b*, mandibular plate; *c*, frontal bristle; *d*, subfrontal bristle; *e*, eyes. (Author's illustration.)

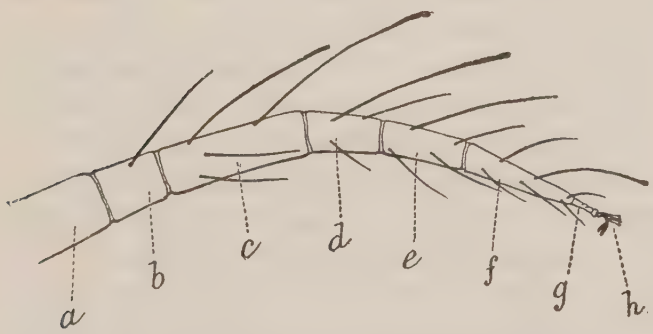


FIG. 41.—*Tetranychus*, leg: *a*, Coxa; *b*, trochanter; *c*, femur; *d*, patella; *e*, tibia; *f*, tarsus; *g*, onychium; *h*, claws. (Author's illustration.)

6. Palpi very slender, and not showing plainly the claw and thumb arrangement; mandibles not elbowed near base..... 7
   Palpi stouter, showing plainly the claw and thumb arrangement..... 8
7. Legs transversely wrinkled; large, bordered ventral apertures; eyes present .....*Tenuipalpus*.
   Legs not transversely wrinkled; ventral apertures smaller; eyes indistinct .....*Tetranychoides*.
8. Prostigma in a horn each side at base of mandibles; body short and broad, with large prominent spines above.....*Tetranychopsis*.
   Prostigma not in a horn, or else body not with spines..... 9
9. Mandibles styliform, elbowed near base; and with a supramandibular plate; body not elongate, and thumb not extending much beyond claw.....*Tetranychus*.
   Mandibles less styliform, not elbowed near base; no supramandibular plate. 10
10. Coxæ close together, body rather short.....*Acheles*.
    Coxæ in two well-separated groups; body elongate..... 11
11. Thumb extending much beyond the claw.....*Caligonus*.
    Thumb barely extending beyond claw.....*Stigmaeus*.

The genus *Acheles* (fig. 48) (=*Syncaligus*, formerly called *Caligonus*) has two described species from the United States—*A. conspicuus* Berl. and *A. cardinalis* Ewing. The one figured appears to be *A. conspicuus*, or a closely allied form. The dorsal surface shows three divisions in front, rather indistinctly. They are minute reddish mites occurring in moss and are not known to spin a thread. Like *Raphignathus*, they may be predaceous on the minute forms that are common in moss. *Raphignathus* (fig. 50) has a broad body with short legs, and is peculiar on account of the way the dorsal surface is divided up into little areas. Our two described species are very minute forms and occur singly in moss and are possibly predaceous.

FIG. 42.—*Tetranychus:* Genital organs. (Author's illustration.)

In *Neophyllobius* the body is short and the legs are very long; the tarsal joint slightly swollen in the middle and ending in two claws. One species, *N. americanus* Banks (fig. 53), occurs on oak leaves in Alabama, and another has been taken in moss in Illinois. In the latter species the tarsus is only very slightly swollen. *Tetranychopsis* (fig. 51) is known from one species from Canada found on the leaves of basswood. It lives socially after the manner of *Tetranychus*.

FIG. 43.—Three styles of claws of *Tetranychus*. (Author's illustration.)

In *Tenuipalpus* the palpi are very small and slender and end in two or four short bristles. The species are smaller than *Tetranychus* and red in color. There are several species in our country. *Tenuipalpus californicus* Banks (fig. 52) appears to be very numerous on the oranges and lemons in California and doubtless causes some injury. Inasmuch as it is very small and does not breed very fast, it will probably never be a pest of prime importance. It may be destroyed by the treatment used against "red spider." *T. inornatus* Banks occurs on various herbs and bushes in the South. They usually occur in small colonies scattered over the leaves. Another species occurs on the under surface of grape leaves in the South, the colony usually near the forking of a vein. Still another form, *T. cardinalis* Banks, has been taken on the bark of ash trees in Arizona. An European species, *T. coronatus* Can. and Fanz., has been found on juniper trees in Colorado, probably imported, and doubtless many other species await discovery.

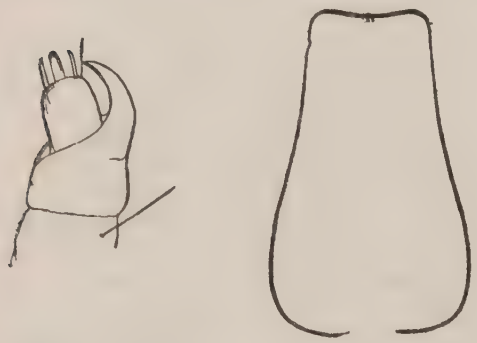


FIG. 44.—*Tetranychus gloveri:* Palpus and mandibular plate. (Author's illustration.)

In the genus *Bryobia* one species, *B. pratensis* Garman (figs. 45, 46), known as the clover mite, is very abundant in many localities. In the West it is injurious to fruit trees. In the East it more commonly affects clover and annual plants. *Bryobia* usually deposits its eggs on the trunks and branches of trees. Sometimes they are so numerous, occurring several layers thick, that they give the branches a distinctly red appearance. They are red, very small and round, and are often mistaken for the eggs of plant lice. The young hatch early in spring, crawl out on the leaves, and

feed. There are about three broods a year. The winter is spent in the egg stage, and also sometimes as adult. With the approaching cold of winter the mites often crawl into houses seeking shelter, much to the annoyance of the occupants. Clover and other infested plants should not be allowed to grow close to the house. Both the mites and their eggs can be killed by a spray of kerosene emulsion; atomic sulphur is used in California. Another *Bryobia*, with longer legs, occurs on alfalfa in the Southwest.

In *Tetranychus* the body is subpyriform and provided above with about 24 to 36 bristles arranged in four rows. The species of this genus can spin a thread, which, when they are very abundant, becomes a dense mesh or web, visible at a considerable distance. The spinning organs are said to be located in the head of the mite, with openings near the base of the mandibles, the thread combed out by the palpi. The web does not appear to afford the mites any protection, but at times seems to serve to hold the eggs in place. It may be either on the upper or lower surface of the leaf. Ewing considers that the web serves to hold the mites while molting. The old skins are usually found attached to the web. In molting the skin splits across the body over the furrow between the cephalothorax and abdomen, each part being worked off separately by the motions of the mite. *Tetranychus* hibernates in the adult condition. Dugès has found *T. telarius* Linn. under stones in winter, and Hanstein has taken them on fallen leaves and in soil under trees. They remain breeding on leaves late in the autumn, even into December. Weber and Voss claimed that it was the larvæ that wintered, but Hanstein says he found only adult females in the winter. Weldon has found *T. bimaculatus* Harvey in Colorado wintering in the soil often 10 feet from the tree. Most of them were found near the crown of the

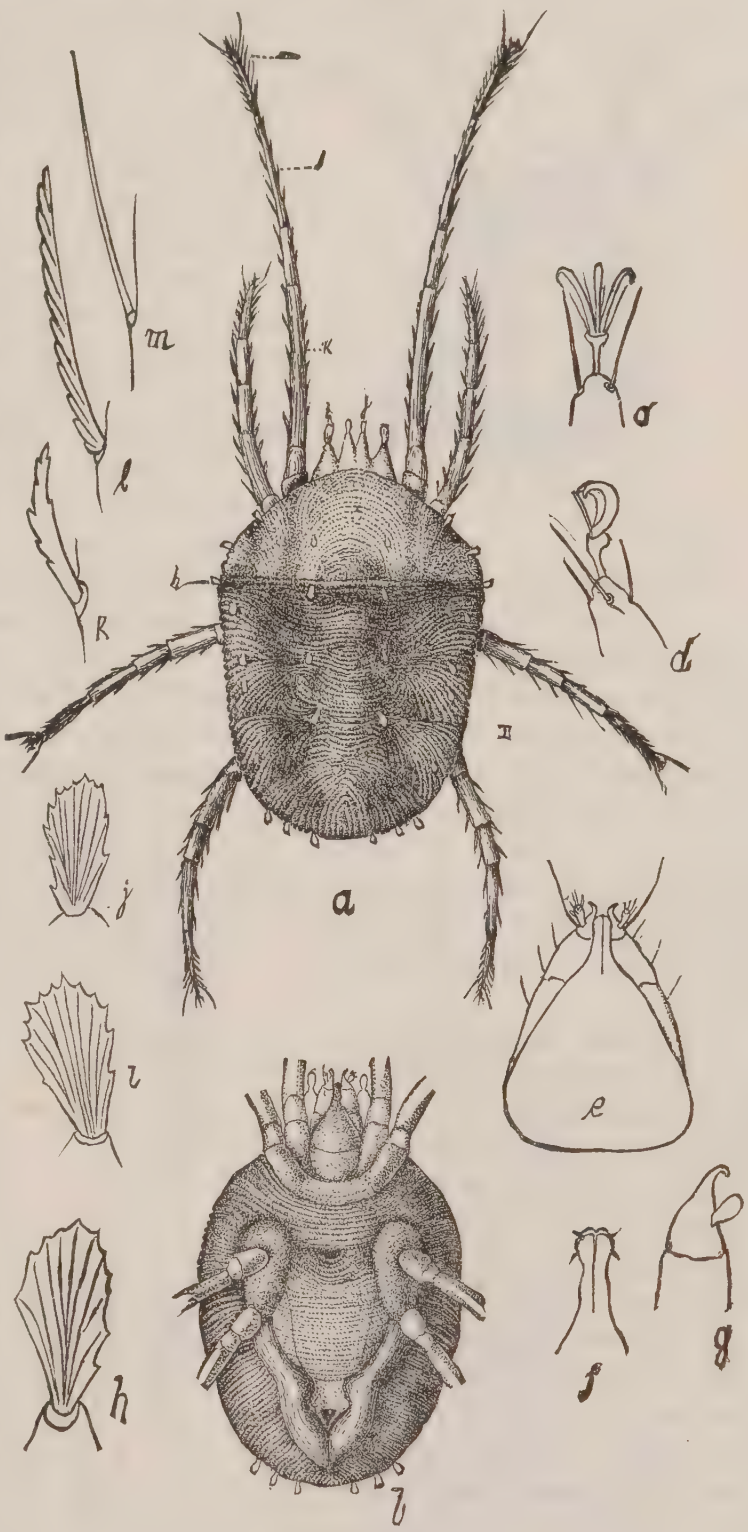


FIG. 45.—*Bryobia pratensis: a*, Female from above; *b*, female from below; *c* and *d*, tarsal claws; *e*, beak from below; *f*, beak from above; *g*, palpus; *h*, *i*, *j*, *k*, *l*, *m*, scales and spines of varying shape. (From Riley and Marlatt.)

tree. In the spring they crawl out, ascend the trees, and deposit eggs on the opening foliage. Each female may lay from 5 to 10 eggs a day for a period of 8 to 12 days. The young hatch in from 3 to 5 days, and in about 5 days more are adult. A succession of broods is continued throughout the summer, but wet weather is apt to stop or greatly retard their development.

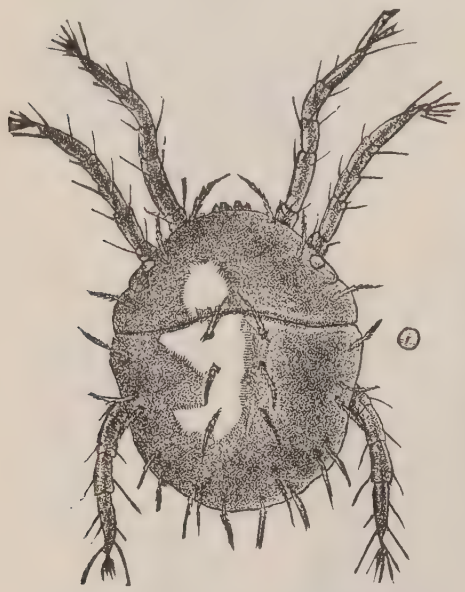


FIG. 46.—*Bryobia pratensis:* Larva. (Author's illustration.)

The mites ordinarily move slowly, but when disturbed can run quite rapidly. For the greater part of the time they remain in one place, sucking the juices from the leaf. In the spring some species attack the buds. Several of our species are very abundant and destructive. The common greenhouse species, known as the "red spider," and which also occurs on many outdoor cultivated plants, is *T. bimaculatus* Harvey (fig. 38). It is probably the *T. cucumeris* of Boisduval. Specimens of this species often vary greatly in coloration; the members of each colony, however, usually being alike. In the South *T. bimaculatus* Harvey is common on violets and from them has spread to cotton fields, where in some localities it works considerable damage. *T. mytilaspidis* Riley is abundant on orange leaves in Florida. In this species the abdominal bristles arise from warts or tubercles, and the tarsus has two simple claws. The most abundant species on orange is a yellowish form—*T. sexmaculatus* Riley. At times it is a very serious pest to orange culture, and an article upon it is found in the Report of the Entomologist for 1889. It occurs on the under surface of the leaves. The eggs are colorless or pale greenish-yellow.

T. pratensis Banks is a pale greenish species abundant in some parts of the West on alfalfa and other field crops. *T. opuntiæ* Banks is very injurious to the prickly pear cactus in Texas. It is wholly bright red in color. An European species, *T. gibbosus* Can., with very short legs and short hairs on the broad body, has been taken on spruce trees in Canada, but possibly only introduced. *T. pilosus* Can. et Fanz. also occurs in Canada and New Jersey, where it does much damage to the leaves of fruit trees.

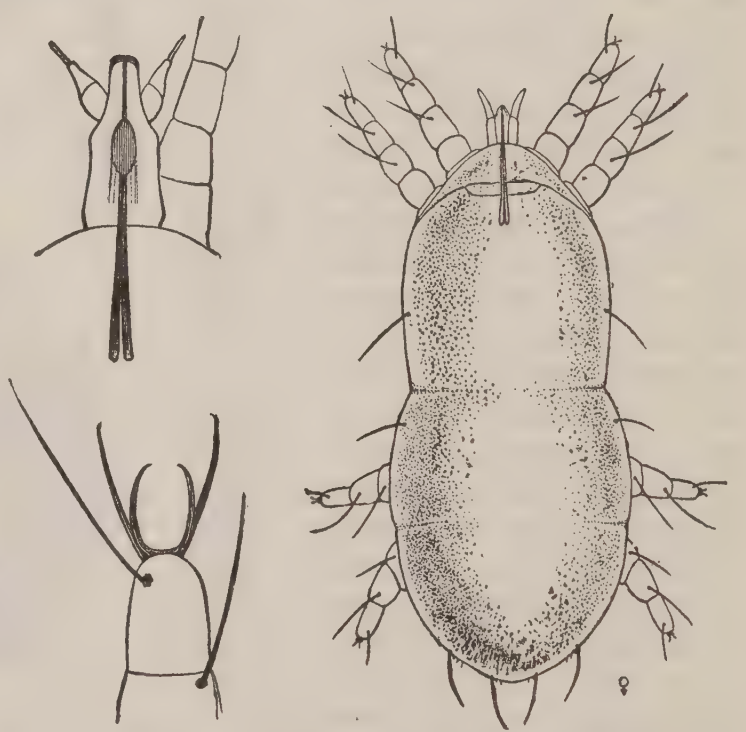


FIG. 47.—*Stigmaeus floridanus:* Mite, mouth-parts, and claws. (Author's illustration.)

In *T. bicolor* Banks, a species common on the leaves of oak and chestnut, the tarsus has but one claw. A form occurring on cotton in Louisiana is known as *T. gloveri* Banks (fig. 44); it is bright red and greatly resembles the common greenhouse species. There are several remedies for red spider. One is to keep the plants moist, spraying them with water once a day. But the best remedy is flowers of sulphur applied either

as a dry powder or lime-sulphur used as a spray. McGregor advocates the use of potassium sulphid, 3 pounds to 100 gallons of water. Bisulphid of lime is also an effective remedy, and tobacco water is sometimes used.

Trägårdh has recently revised the Swedish *Tetranychus*, and divided the genus: *Tetranychus* is retained for species with the claw divided into four parts; *Paratetranychus* for those with claw entire, and *Schizotetranychus* for those with claw in two parts; the latter genus includes *T. mytilaspidis* and *T. pratensis;* while *T. modestus*, *T. simplex*, and *T. yothersi* go in *Paratetranychus*.

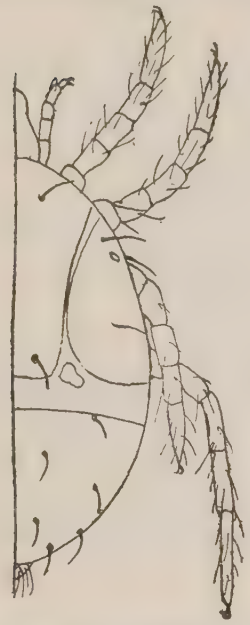


FIG. 48.—*Acheles.* (Original.)

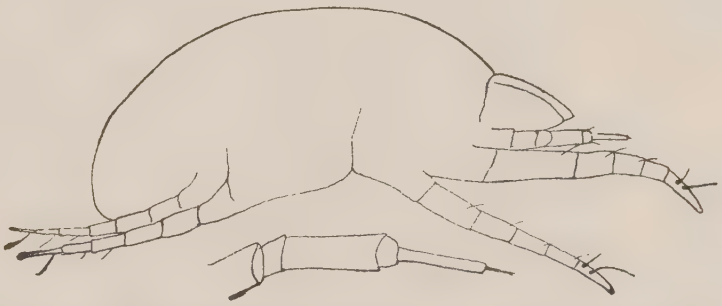


FIG. 49.—*Tetranychoides californica,* and palpus enlarged. (Author's illustration.)

The species of *Stigmaeus* are elongate and have short legs. They are smaller than *Tetranychus* but live in the same manner. Our one species, *S. floridanus* Banks

FIG. 50.—*Raphignathus brevis.* (Original.)

FIG. 51.—*Tetranychopsis spinosa.* (Original.)

(fig. 47), occurs upon the bases of the imbricated leaves of the pineapple. It is of considerable economic importance, owing to the fact that its punctures give certain destructive fungi access to the tissue of the leaf. The remedy, Prof. Rolfs found, is to place a small quantity of tobacco dust in the bud of the plant, the dew and rain wash-

ing it down upon the mites. One application is usually sufficient. Berlese has proposed *Eustigmaeus* for species of *Stigmaeus* with short abdomen and *Macrostigmaeus* for those with slender subcylindric abdomen. These species have been taken in moss.

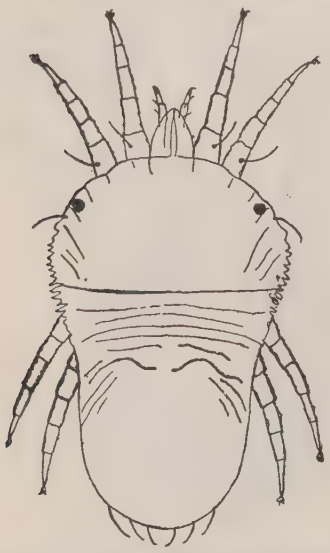


FIG. 52.—*Tenuipalpus californicus.* (Author's illustration.)

The species of *Tetranobia* and *Tetranychina* have slender legs, the first and last pairs usually longer than the body; they occur on plants after the manner of *Bryobia* and are sometimes injurious. The few forms known occur in the southern or western parts of our country. *Stigmaeopsis celarius* Banks is similar to *Tetranychus* in appearance; it makes small white webs on bamboo; the mites live under the webs; it now occurs in Florida and California.

Caligonus (redescribed as *Eupalopsis*) differs from *Stigmaeus* in having the thumb to the palpus very slender and reaching much beyond the end of the claw.

Tetranychoides is based upon one species, *T. californica* Banks (fig. 49), which occurs in small colonies on the leaves of orange. Each colony is usually in a slight depression and is evident to the naked eye as a snow-white patch, this appearance being due to the fact that the molted skins are retained attached to the leaf. The mites, which are almost colorless, and their eggs are located among these molted skins. They are not as yet numerous enough to do any appreciable damage.

Ewing has described a species of *Stigmaeodes* from Iowa; it differs little from *Stigmaeus*, the body being more slender and with several hairs between the claws.

Trägårdh has described a genus, *Pimeliaphilus*, from Egypt, near *Acheles;* the coxæ appear to be separated in groups and the palpus has a distinct thumb. The female has a small anterior shield and other small shields at base of the dorsal bristles. The tarsi have two simple claws; otherwise it is a *Tetranychus*. The same author describes a form from Egypt as *Phytotipalpus*. Its general structure is similar to *Tenuipalpus;* it lives in small galls on the bark of acacia trees, and Trägårdh has traced its development, which presents nothing unusual.

Red-spider damage is common in nearly all foreign countries, but the generic positions of the mites that cause it are not easily discernible from the meager descriptions. In India and Ceylon one species, called *Tetranychus bioculatus* Green is a very serious pest to the tea plant.

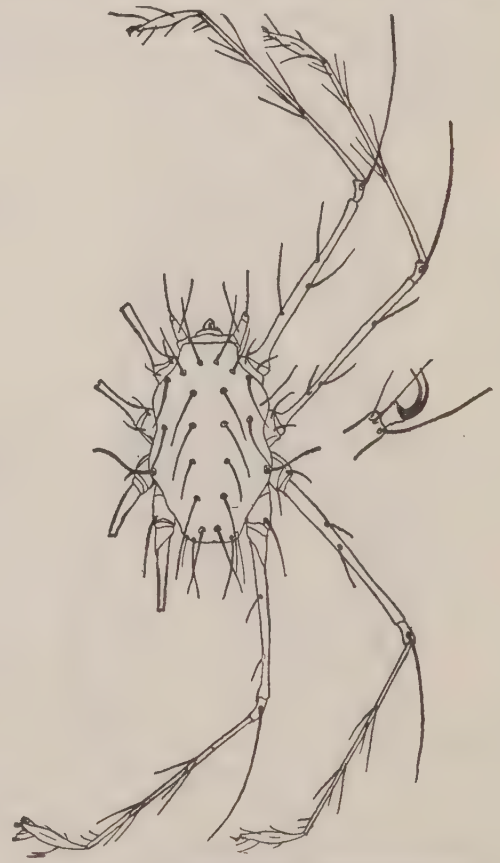


FIG. 53.—*Neophyllobius americanus* and tarsal claw. (Author's illustration.)

FAMILY ERYTHRÆIDÆ.

These common mites are similar in many ways to the harvest-mites (Trombidiidæ) and by many authors have been united to them. They are much like *Trombidium* in appearance, but nearly all are of more slender proportions and more rapid in motion. The body is usually divided, although not so plainly as in the Trombidiidæ, into two parts. The cephalothorax is quite large and on the same plane as the abdomen. Along the middle of the cephalothorax is a line or furrow, known as the dorsal groove or crista. It is usually enlarged at the posterior end, sometimes in the middle, and

also at the anterior end, where it often includes a frontal tubercle. There are one or two simple eyes on each side of the cephalothorax; they are always sessile. In one

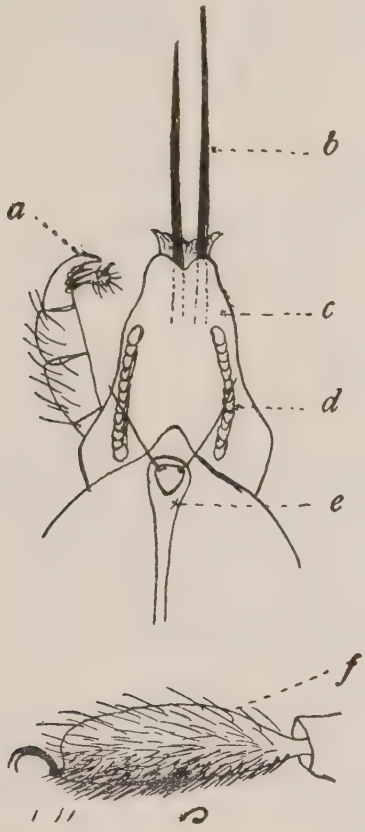


FIG. 54.—*Erythæus:* *a*, Palpus; *b*, mandibles; *c*, beak; *d*, tracheal pores; *e*, dorsal groove; *f*, tarsus. (Author's illustration.)

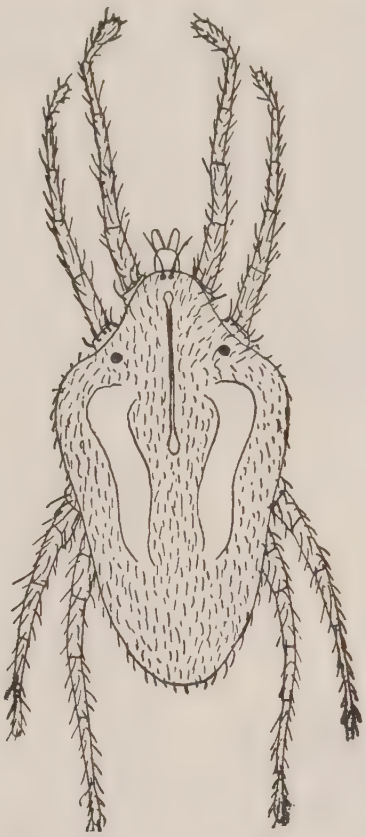


FIG. 55.—*Atomus maculatus.* (Author's illustration.)

genus (*Smaris*) there are also two eyes close together near the middle of the anterior margin. The palpi are prominent, five-jointed, the last forming a "thumb" to the preceding, which ends in a claw. The mandibles (fig. 54) are slender, needle-like, and retractile, thus differing greatly from those of *Trombidium* and forming the warrant for a separate family.

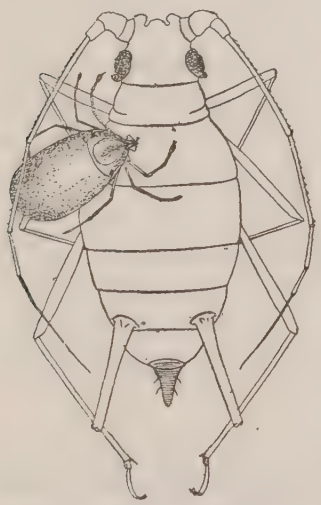


FIG. 56.—Leptus of *Erythraeus* on a plant louse. (Original.)

The legs are commonly quite slender, the hind pair sometimes more than twice as long as the body. They are seven-jointed and terminate in two small claws. The last joint, or tarsus, is nearly always shorter than the preceding joint, and in the first and fourth pairs often swollen. The body and legs are densely covered with bristles or hairs, sometimes both. The hinder pair of legs are always quite remote from the anterior pairs. The genital opening is between the hind coxæ, and the anal opening is usually close behind it.

These mites are usually found on the ground, sometimes in very hot situations, and run over the surface or on low plants with great rapidity. Other species occur in moss or under fallen leaves in woods, and one is abundant among the rocks near the top of Mount Washington. Several species appear to live in colonies, but most are solitary in habit. The eggs are deposited on the ground or under stones, often in clusters. The larva (fig. 56) is a six-legged mite attached to insects. When full fed it drops to the ground and becomes quiescent, and after a varying time transforms to the adult.

There are several genera in the family, but only four are so far known from the United States.

1. Legs I and II with stout spines, each metatarsus with two little raised disks ..... *Caeculisoma.*
   Legs without spines and without disks 2
2. Mouth parts retractile 3
   Mouth parts not retractile 4
3. No crista; usually six eyes; palpi four-jointed ..... *Smaris.*
   Crista present; only four eyes; palpi five-jointed ..... *Fessonia.*
4. Hind tarsi with plume of long hairs; two eyes each side on body ..... *Eatoniana.*
   Hind tarsi without the plume 5
5. A distinct suture between cephalothorax and the abdomen; but one eye each side ..... *Belaustium.*
   No distinct suture 6
6. Two eyes each side on body; legs IV very long ..... *Erythraeus.*
   One eye each side; legs IV shorter ..... *Atomus.*

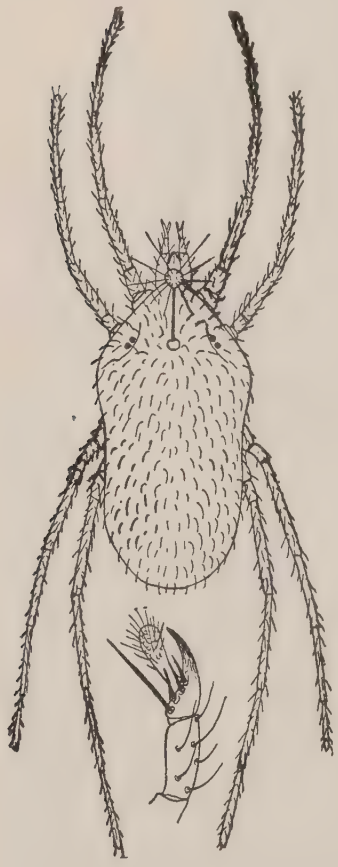


FIG. 57.—*Erythraeus simplex* and palpus. (Author's illustration.)

Thor, who has recently published on this and allied families, makes *Smaris* (fig. 58) the type of a special family. He finds that in this genus there are no spiracles near the beak, as in other Prostigmata, and that there are no large tracheal trunks in the body. There are a great many fine tracheæ in this mite, and Thor believes that respiration is effected through the skin, the structure of which is rather peculiar. Upon these differences he bases a family; however, in my opinion this is but more evidence (if such is needed) of the uselessness of a classification based on the respiratory system.

In *Smaris* the mouth parts are retractile, and so are often invisible; the palpi are four-jointed and there is commonly an extra pair of eyes near the anterior margin, making six in all. These median eyelike spots are, perhaps, not true eyes but homologous with the crista metopica of *Erythraeus*.

In *Fessonia* the mouth parts are less retractile than in *Smaris*, and there are but four eyes. The palpi are five-jointed and the dorsal groove is sometimes swollen in the middle.

In *Erythraeus* the mandibles are retractile, there are but four eyes, and the palpi are five-jointed. We have many species of this genus, and several of them are common and widely distributed. They are predaecous and suck the juices from any small insect that they are able to catch. One species has been found preying on the gloomy scale (*Chrysomphalus tenebricosus* Comst.) and others are found feeding on the San José scale and other scale insects. In this situation they are often the prey of aphis lions (*Chrysopa*).

The larva that in Europe occurs commonly on phalangids and which was described by Oudemans as a new species (*E. ignotus*) has been shown by Evans and by Bruyant to be that of *E. nemorum* Koch. In this country we also have a species whose larva is frequently attached to daddy-long-legs, but it has not been connected with the adult form. The generic name *Erythraeus* was formerly applied to a mite of another family, but it is clear that its type species and original application bring it into this family practically to replace *Rhyncholophus*.[1] The genus *Atomus* Latreille was made for a larva of this family, the adult being congeneric with *R. nemorum*.

[1] *Ritteria* Kramer is not available, as the author neglected to place any species in it.

Leptus, with the same type species, and *Achorolophus* Berlese are synonyms. Many of our species will go in *Atomus*. *Belaustium* will include some of the heavier, shorter legged species, which have more resemblance to *Trombidium*. Our species have not been apportioned but described under *Rhyncholophus* (*Erythraeus*). Most of them, like *E. simplex* Banks (fig. 57), are uniform reddish in color, but *Erythraeus cinctipes* Banks has prettily banded legs, and (*E.*) *Atomus maculatus* Banks (fig. 55) has several large pale spots on the dorsum, while *E. parvisetosus* Ewing is almost wholly black. Ewing has recorded finding a specimen of this species carrying several of its larvæ on its back, but perhaps they were more probably red bugs. One of our species, *E. longipes* Banks, has such extremely long legs that it resembles a minute phalangid. Several species of the genus *Eatoniana* occur in southern Europe and northern Africa; they are remarkable on account of a plume of long hairs on the hind legs. The South American genus *Caeculisoma* differs from *Erythraeus* and *Smaridia* in having two little buttonlike elevations near the tip of each metatarsus, as shown in figure 59.

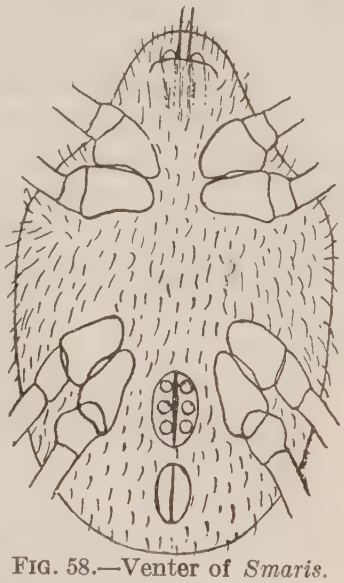


FIG. 58.—Venter of *Smaris*. (Author's illustration.)

FAMILY TROMBIDIIDÆ.

The "harvest mites," as they are popularly called, are recognized by the body being divided into two portions, the anterior (cephalothorax) bearing the two anterior pairs of legs, the palpi, mouth parts, and eyes; the posterior (abdomen) is much larger and bears the two posterior pairs of legs. The mandibles (fig. 64) are chelate; at least there is a distinct jaw or curved spinelike process. They also differ from the allied Rhyncholophidæ in that the last joint of leg IV is not, or very slightly, shorter than the penultimate, and in that the last joint of leg IV is not swollen. The last joint of leg I (fig. 63) usually is swollen, often more so than in the Rhyncholophidæ. They are always red in color, some, however, being much darker than others. The body is covered with bristles or feathered hairs, according to the species. The palpi are five-jointed, quite prominent, often swollen in the middle, the penultimate joint ending in one or two claws, the last joint (often clavate) appearing as an appendage or "thumb" to the preceding joint. The legs are seven-jointed; the tarsi terminate in two small claws (fig. 62). The legs are clothed in the same manner as the body. There are two eyes (fig. 61) upon each side of the cephalothorax, quite frequently borne on a distinct pedicel.

FIG. 59.—*Caeculisoma:* Tarsus I. (Original.)

FIG. 60.—Egg of *Trombidium*. (Author's illustration.)

Along the median line of the cephalothorax there is commonly a crista (crista metopica) or dorsal groove similar to that of the Rhyncholophidæ. This crista is

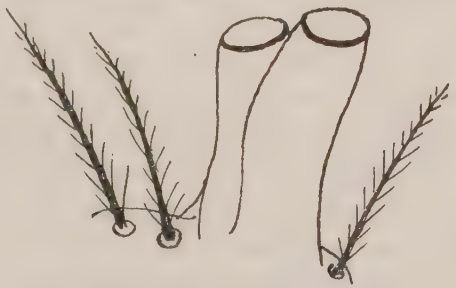


FIG. 61.—Eye of *Trombidium*. (Author's illustration.)

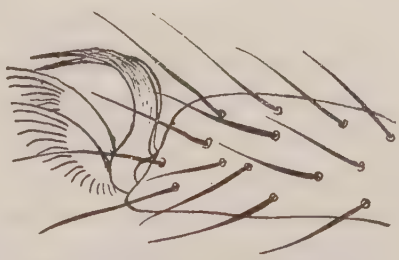


FIG. 62.—Claws of *Trombidium*. (Author's illustration.)

enlarged at the middle or posterior end into a triangular area, called the areolæ or sensillæ, in which are two pores from which arise bristles. Oudemans terms these the pseudostigmata and pseudostigmatic organs; the latter are sometimes clavate

at or near tip. There is no proof that these are homologous with the organs of the same name in the Oribatidæ, although it is possible. Sometimes these organs are present, although the crista is absent, and in one species there are two pairs of the organs. The function of these organs is entirely unknown. The genital aperture is situated between the hind coxæ; the anal opening is smaller than the genital and placed a little behind it.

The larvæ (figs. 65, 66, 67) are six-legged mites and parasitic on various insects. They, with other larval forms, were formerly supposed to be adult and to constitute a distinct family under the name of Microphthiridæ. Three of the genera of that family, *Leptus*, *Ocypetus*, and *Atoma* (or *Astoma*), are now known to be larval Trom

FIG. 63.—Leg I of *Trombidium*. (Author's illustration.)

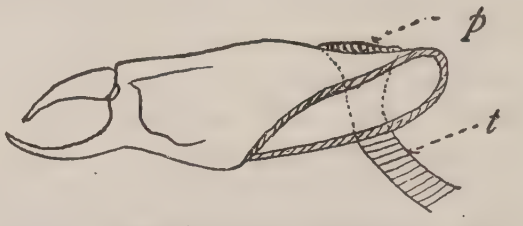


FIG. 64.—Mandible of *Trombidium*: *p*, Tracheal pores; *t*, trachea. (Author's illustration.)

bidiids. Some of these larvæ are, in certain localities, very numerous, and will attach themselves to man, causing intense itching, soreness, and even more serious complications. They have received the popular name of "red bug." In parts of the Southern States the "red bugs" are often a source of great annoyance. They enter pores of the skin and produce inflamed spots. It is an unnatural situation for the mites and they soon die, but the waiting is not pleasant. They can be killed by anointing the affected spots with an ointment or salve containing sulphur. Some recommend sponging with a weak solution of carbolic acid (an ounce to a quart of water) after a soap bath. Allied species occur in all warm countries and have become obnoxious enough to receive a popular name. In France, where they are often very troublesome, they are called "rouget" or "aoutat," and are the cause of "erythema autumnale." In parts of Scotland it is called "berry bug." In parts of Germany a severe infestation is known as "stachelbeerkrankheit." In England it is called the "harvest mite" and "gooseberry bug." In Mexico red bugs are known as "tlalsahuate," in Japan as "akamushi," and in parts of the West Indies as the "bête-rouge." In Celebes they are known as the "gonone," in parts of New Guinea as the "arkan," and in Guiana are called "batata mite." In Japan they are considered by some to transmit the "kedani" disease, or river fever, but the evidence is not as yet conclusive. In all these countries they have at times been a serious annoyance to the peasantry and hindered or prevented the harvesting of certain crops. The "red bug" is not the larva of only one species of *Trombidium*, but of several species; in each locality there are apt to be two or three forms of "red bug." In France Bruyant has shown there are at least three forms of "red bug," one of which is the larva of *Trombidium inopinatum* Oudemans, another the larva of *T. holosericeum* Linn., while the adult of the third form is unknown. Evans has found that the larvæ of the European *T. holosericeum* will not attack man; doubtless they feed on insects or small mammals. The female *Trombidium* (fig. 7, p. 13) deposits her eggs in or upon the ground, sometimes as many as 400 together. They are usually brown and spherical, and were by some early writers considered to be fungi. The outer skin or chorion soon splits,

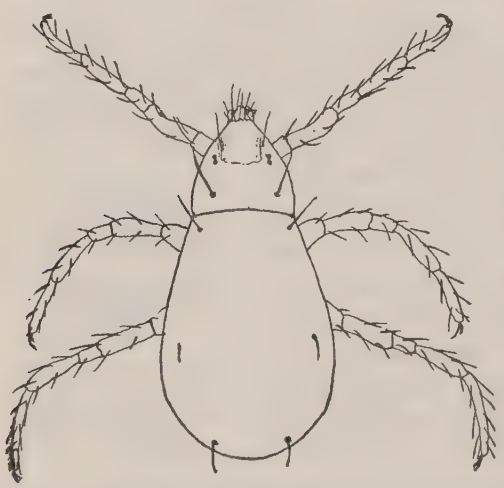


FIG. 65.—The larva (leptus) of a *Trombidium*. (Author's illustration.)

dividing the egg (fig. 60) into halves and exposing the pale vitelline membrane; this stage is the "deutovum" of Claparède.

The newly hatched larva is circular or ovoid in outline, with three pairs of legs each tipped with two or three prominent claws. After attaching to the insect the larva becomes elongate and swollen with food. When full fed it drops off, seeks shelter in the soil or under a stone, and remains motionless for several weeks. The body swells and changes in form as the nymph is developed within; this stage is called by Henking the nympho-chrysalis. When ready the nymph issues from the cracked skin of the larva, and after feeding and growing, again resumes a state of repose; this stage preceding the adult condition is known as the teleio-chrysalis; from this comes the adult mite.

FIG. 66.—Larva of *Allothrombium* and mouth parts. (Original.)

The mature mite is not parasitic, but wanders about feeding on small insects, as plant lice, young caterpillars, and one species, *T. locustarum* Riley, is known to destroy a great many grasshopper eggs. A French species has been found destroying the root forms of the dreaded *Phylloxera*. The adult hibernates in sheltered places or in the soil; the eggs are laid in the spring, and there appears to be but one brood a year. Only a few forms have been bred; the larva of one of them is common on the house fly in autumn, and a similar form occurs on mosquitoes.

The old genus *Trombidium* has been divided into many genera and subgenera, mostly by Berlese. The characters used do not refer to the appearance of the mite and are often difficult to tabulate; the genera that may merit separation are given in the following table:

1. No crista metopica ..... *Trombella.*
   Crista metopica present 2
2. Sides of body with projections ..... *Chyzeria.*
   Body without projections 3
3. Claws with a pulvillus; eyes pedunculate; one claw at tip of palpus .. *Allothrombium.*
   No pulvilli 4
4. No eyes 5
   Eyes present 6
5. Crista enlarged near middle ..... *Typhlothrombium.*
   Crista enlarged at end ..... *Trombicula.*
6. Eyes sessile; palpus with two claws at the tip 7
   Eyes pedunculate 10
7. Crista enlarged but once 8
   Crista enlarged twice 9
8. Enlarged only at end; abdomen higher than the cephalothorax .. *Microtrombidium.*
   Enlarged only near middle; abdomen and cephalothorax of same height. *Tanaupodus.*
9. Crista enlarged at middle and at end ..... *Eutrombidium.*
   Crista enlarged twice near the middle ..... *Diplothrombium.*
10. Crista enlarged near middle 11
    Crista enlarged near end 12
11. Eyes long pedunculate; no teeth at base of the palpal claw ..... *Dinothrombium.*
    Eyes short pedunculate; teeth at the base of the palpal claw .... *Podothrombium.*
12. Crista enlarged near anterior end; eyes long pedunculate; no teeth near palpal claw; legs rather short ..... *Trombidium.*
    Crista enlarged near posterior end; eyes short pedunculate; teeth near palpal claw; legs very long ..... *Johnstoniana.*

Our forms have been described under the name *Trombidium*, and, while their repartition into the new generic segregates has not as yet been attempted, it is probable that we have representatives of most of these new genera. Berlese has recently published a revision of the family, but he had very few species from our country, several

of which are still undescribed. Kolenati's genera *Otonyssus* and *Peplonyssus*, parasitic on bats, appear to be larval trombidions. Many of the European larvæ have lately been described as new species, but it is a very undesirable practice. Oudemans has given the characters of the two groups of Trombidion larvæ as follows:

1. Two median dorsal shields.....*Allotrombium.*
   But one median dorsal shield.....*Trombidium.*

Several of our trombidions are very common, and *T. sericeum* Say is often seen crawling about in early spring, its bright red color and silky vestiture attracting the atten-

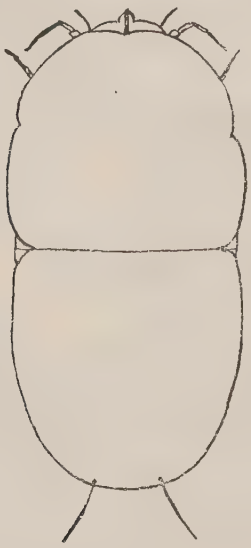


FIG. 67.—Larva of *Trombidium* from cricket. (Original.)

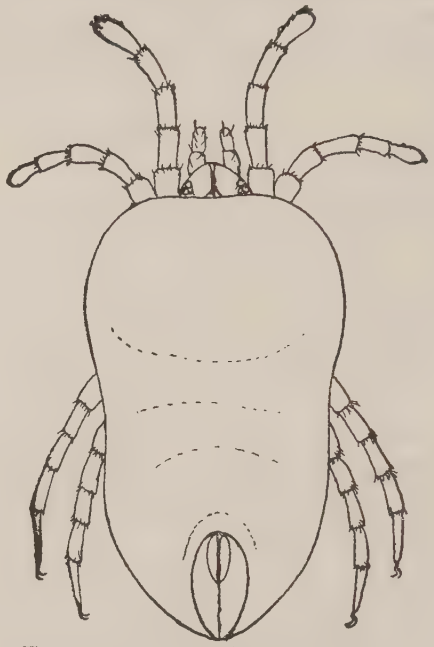


FIG. 68.—*Trombidium locustarum:* Male. (Author's illustration.)

tion of even the most casual observer. In the Southwest there is a very large, hairy species, *T. magnificum* Le Conte (fig. 70), which appears at times in enormous numbers, often after rains, and in parts of Arizona is called "angelitos" by the Mexicans. A similar form, but spotted with white, *T. superbum* Banks, occurs in Texas and New Mexico, and has habits similar to those of *T. magnificum*. *T. giganteum* Riley (fig. 69), is a large red form feeding on grasshoppers.

In *Microtrombidium* there are two claws at the end of the palpus. *M. locustarum* Riley (fig. 68), feeds on eggs of grasshoppers. Most of the species are of good size,

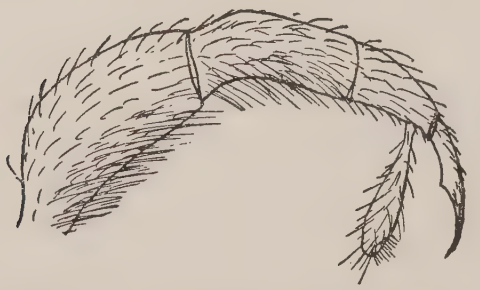


FIG. 69.—Palpus of *Trombidium giganteum.* (Author's illustration.)

FIG. 70.—Palpus of *Trombidium magnificum.* (Author's illustration.)

some among the largest of the mites. In the Tropics there is a group of large species (*Dinothrombium*), of which *T. tinctorium* Linnæus is perhaps the best known. It attains a length of about one-half inch, and occurs in the warmer parts of Africa. It was supposed to be used as a dye in olden times, but does not seem to be so used now. One of our species, *T. maritimus* Banks, lives under stones between tide marks on the seashore, and sometimes feeds on a maritime coccid (*Ripersia maritima* Cockerell).

The genus *Trombella* is founded on a curious South American species, and *Chyzeria* represents a form from New Guinea, which has projections along the sides of the body.

Family CÆCULIDÆ.

A few mites of peculiar appearance, somewhat like *Nothrus* of the Oribatidæ, but structurally allied to *Trombidium*, constitute this family. They are rather large mites, of somewhat rectangular shape, and of a leathery texture; the legs are very rough, and the anterior pairs provided with a row of long spines. They terminate in two claws. The coxæ are arranged close together in a radiate fashion. The dorsum shows a transverse furrow, indicating the separation of cephalothorax and abdomen. The former is provided with a median shield, and from each posterior side arises a pedicel bearing two eyes similar to those of *Trombidium*. The abdomen is provided with two or more shields, according to the species. The ventral openings are very large and close together, each closed by flaps or valves. The mouth parts are small and obscure, but the palpus is stout, five jointed, the first and third joints very small, the penultimate ending in a curved spine, the last forming a "thumb." The mandibles are stout and terminate in a curved claw. They are concealed in the large conical rostrum. The species are brown in color. Very little is known regarding their habits and nothing as to life history. They occur in moss, among fallen leaves, or in moist places. They move very slowly and feign death when disturbed. But one genus, *Caeculus*, is known. Several species occur sparingly in southern Europe and northern Africa. One, *Caeculus americanus* Banks (fig. 71) was discovered by Hubbard in southern California, and another is found among decaying leaves in the Eastern States.

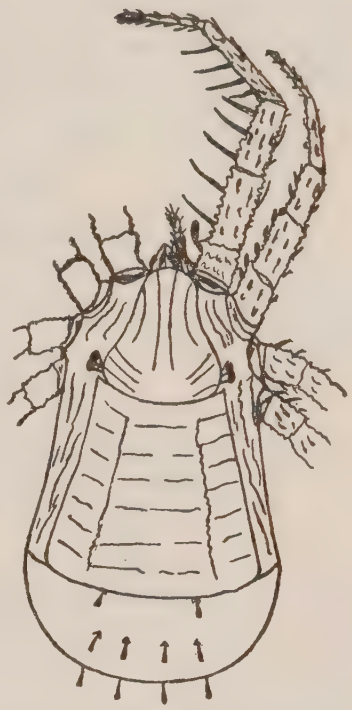


Fig. 71.—*Caeculus americanus*. (Author's illustration.)

Superfamily HYDRACHNOIDEA.

Family HYDRACHNIDÆ.

Since O. F. Müller described the Danish species in 1781, the water mites have attracted more attention and study than any other family of Acarina. A large number of important papers have been published, particularly on the European fauna, and one number of "Das Tierreich" (fascicule 13) is devoted to them. The body is commonly short, usually high, and sometimes nearly spherical. It is entire, there being no division into cephalothorax and abdomen. The legs arise close together on the anterior part of the venter, and often in a radiate arrangement. They have one or two simple eyes each side; in some cases these are situate close to the median line. In one group the two eyes each side are situate on a common chitinous plate called the eye capsule. The tegument is often soft, but sometimes provided with dorsal shields or covered with a pitted cuirass. The mouth parts are often hidden under the anterior margin of the cephalothorax. The beak (rostrum or capitulum) is usually elongate pyriform, and the mandibles are two-jointed, with a clawlike terminal joint; sometimes they are elongated into needlelike piercing organs. The palpi (maxillary) are of four or five joints, the basal one often very small, the apical one sometimes folding against the penultimate. The palpi vary greatly in shape, and are of great value in classification. The legs are usually of seven joints, rather subequal in length, although the fourth pair is commonly the longest. The coxæ are often broad and entirely united to the venter, and frequently to each other, thus forming coxal or epimeral plates—sometimes four, sometines three, and in a few genera united into one plate. The tarsi often terminate broadly, usually have two claws, and are provided with hairs and bristles. Sometimes there are rows or tufts

of hairs for assistance in swimming; these are most numerous on the posterior legs. On the venter are the genital and anal openings; sometimes the former is very far back, nearly or quite on the posterior margin. There is usually a group of sucking disks (fig. 76) each side of the genital aperture, the number and position of which are quite characteristic of each species. On the dorsal side of the rostrum (capitulum) are two spiracles that lead to the tracheæ; in some forms there are no tracheæ. The adult mite lives free in the water as a rule, but in *Atax* they are parasitic in the gills

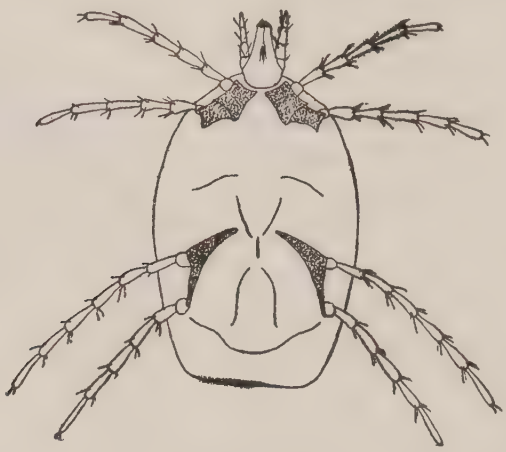


FIG. 72.—*Limnochares:* Venter. (Author's illustration.)

FIG. 73.—*Limnochares:* Eyes and dorsal plate. (Author's illustration.)

of mollusks. Hydrachnids are the most beautifully colored of all acarians. Some are a delicate green, others blue with yellow marks, some species are very brilliant, and others are prettily marked with yellow and black, but vary considerably in maculation. Hydrachnids are rather above the average size of mites, some species being fully 8 mm. long and most of them over 1 mm.

There are frequently differences in structure between the sexes; in *Arrenurus*, and some other genera, the male (fig. 77) is larger than the female and has an elongated

FIG. 74.—*Eylais* sp. (Author's illustration.)

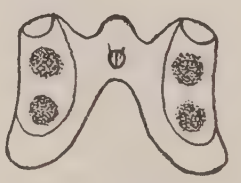


FIG. 75.—Eye plate of *Eylais*. (Author's illustration.)

abdomen tipped with a median projection called the petiolus. In some forms the males have some of the joints of the legs especially modified. In some cases the male is much smaller than the female, and more flattened. The female lays spherical eggs on water plants, stones, or in the mantle folds of lamellibranch mollusks. The eggs on plants are often red in color, placed side by side in a mass and covered with a mucous substance. During the course of development a membrane is separated from the embryo while yet inclosed in the eggshell; the egg in this condition is the deutovum. After the eggshell is broken the embryo continues to develop within this

deutovum. The larva (figs. 80, 81) on hatching is six-legged, and in some cases is parasitic in the respiratory system of mollusks or attached to aquatic insects. Neumann has claimed that in one species of *Limnesia* the form hatching from the egg is eight-legged and therefore a nymph, as in *Spinturnix*. Kramer has arranged the larvæ in three series, which he considers is the basis of classification. As a whole, the larvæ differ greatly from the adults and many were described as different creatures. Some were the basis of the genus *Achlysia*.

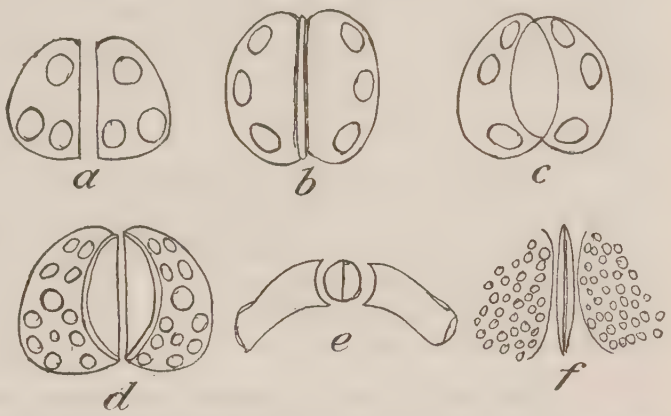


FIG. 76.—Genital suckers of Hydrachnids: *a, Hydrochoreutes, Piona; b, Hydrobates, Mideopsis, Lebertia; c, Limnesia; d, Atax; e, Arrenurus; f, Nesaea.* (Original.)

The larva usually has very small mouth parts. It fastens to an insect by means of hooks at the tip of the short, stout palpi, inserts its jaws, and proceeds to feed. Gradually the body becomes swollen, the legs shrink, and the creature looks like an elliptical egg. The pupa is formed within this saclike body, and from it in time issues the adult mite. Frequently mature insects such as mosquitoes, whose early stages are passed in the water, have many immature hydrachnid mites clinging to them. These mites have made a serious mistake, and out of the water must soon die. It is probable that they were attached to the insect pupa, and at its transformation moved to the adult without suspecting the suicidal result. These mites in the water must often have to change when their host larva molts, so that they realize when a change is imminent, and relax from the old skin at the right time to attach to the emerging insect. It has been noted by Müller that when *Libellula* was heavily infested with the immature stages of certain red water mites there were about as many specimens on the wings of one side as those of the other side, so that the insect had a prettily and evenly maculated appearance. On most insects, however, there is no plan of attachment, but specimens often occur at the ventral base of the abdomen.

FIG. 77.—*Arrenurus* sp.: Male. (Author's illustration.)

Nearly all Hydrachnidæ live in fresh water, a few forms occur in brackish water, and several are known from the littoral zone of the sea. They are sometimes parasitic, as already noticed, and feed on any small animals they can catch, such as small Crustacea, infusoria, and minute insect larvæ. The water mites are found throughout the globe, but appear to be most numerous in temperate regions. Many species inhabit rapid streams and very cold water. Some species are rather sociable and occur in colonies among small patches of water weeds. A great many species have been described from tropical countries, most of which belong to European genera. Over 60 genera and

700 species have been described. The species are often widely distributed and found amid very differing surroundings; but the aquatic environment is, as a whole, more uniform than an aerial one, so that a species may have a distribution that would be very unusual for a terrestrial acarian.

Various classifications have been made, one of which arranges them in 14 families. However, it may be better in this paper to use a less complex system. Dr. Koenike, who has studied these mites very extensively, considers that they represent a suborder, Hydracarina, which he divides into five families, as follows:

1. Eyes in the middle of front 2
   Eyes on the sides 3
2. Eyes situate upon an elongate chitinous plate ..... LIMNOCHARIDÆ.
   Eyes connected by a transverse chitinous bridge ..... EYLAIDÆ.
3. Eyes placed on a small chitinous plate (or eye-capsule); color red 4
   Eyes not on a chitinous plate ..... HYGROBATIDÆ.
4. Body more or less depressed ..... HYDRYPHANTIDÆ.
   Body arched, rounded ..... HYDRACHNIDÆ.

The Limnocharidæ and Eylaidæ have each but one genus, while the great bulk of species belongs to the family Hydrobatidæ. Other writers also have kept these water mites well separated from all other acarians, but most authors now recognize their close relationship with the Trombidiidæ and some merge part of the hydrachnids with the Trombidiidæ. Nordenskiold believes the family to have two separate origins, and therefore not natural. However, their aquatic habit is a convenient, if wrong, incentive for treating them as a unit, and distinct from other families. Moreover, they have usually been studied as a unit, and by persons who have taken little, if any, interest in other acarians.

In the following table are found several common European genera which are not yet recognized from this country, and doubtless other European genera will also be found to occur in North America. Dr. Koenike published a valuable paper on some Canadian forms, and lately Dr. R. H. Walcott and Miss Ruth Marshall have issued several excellent articles on our native species.

1. Living in the sea ..... *Pontarachna*, *Nautarachna*.
   Living in fresh water 2
2. Eyes close together near the median line 3
   Eyes widely separated on the sides 4
3. Hind legs far from front legs, and without swimming hairs; tips of tarsi obliquely truncate; body somewhat divided into cephalothorax and abdomen; in fact the whole creature is trombidiform. (Limnocharinæ) *Limnochares*.
   Hind legs not far from front legs, with swimming hairs; tarsi pointed; no indication of division of body ..... (Eylainae) *Eylais*.
4. Penultimate joint of palpus prolonged beyond base of last or with a tooth or spinelike projection near, or at tip; eye capsule present. (Hydrachninæ) 5
   Penultimate joint of palpus not prolonged beyond base of last, nor ending in a spine; no eye capsule ..... (Hygrobatinæ) 10
5. Mandibles one-jointed, needlelike; abdomen globose ..... *Hydrachna*.
   Mandibles of two joints, with claw at end; abdomen depressed 6
6. Lateral eyes far apart ..... *Diplodontus*.
   Lateral eyes close together 7
7. Without swimming hairs to legs 8
   With swimming hairs 9
8. With a median eye on front part ..... *Thyas*.
   Without median eye ..... *Panisus*.
9. With a median eye on front part 29
   Without median eye ..... *Tanaognathus*.
10. Fifth joint of palpus forming a claw opposable to the apical part of the fourth joint; males frequently have the abdomen extended behind 11
    Fifth joint of palpus not forming a claw opposable to the apical part of fourth joint 12
11. Capitulum or rostrum elongate, of two joints; palpi very small ..... *Krendowskia*.
    Capitulum short, entire ..... *Arrenurus*.

12. Epimera of both sexes united into one plate 13
Epimera (at least of female) not united into one plate 18
13. Fourth joint of palpus with a projection below ..... *Xystonotus.*
Fourth joint of palpus without projection 14
14. Dorsum without a bowed furrow 15
Dorsum with a bowed furrow 16
15. Hind tarsi without claws ..... *Oxus.*
Hind tarsi with claws ..... *Lebertia.*
16. Bowed furrow open in front, ends extending over on venter ..... *Axonopsis.*
Bowed furrow not open in front 17
17. Second joint of palpus with a projection below; genital aperture at tip of body ..... *Aturus.*
Second joint of palpus without projection; genital aperture much before tip of body ..... *Mideopsis.*
18. Fourth tarsus without claws; a long bristle at tip ..... *Limnesia.*
Fourth tarsus with claw as with others 19
19. Genital opening with lip each side nearly covering the disks; palpi with spine below on joint 2 ..... *Sperchon.*
Disks near genital opening fully exposed 20
20. Epimera of female in two groups ..... *Koenikea.*
Epimera of female in three groups; genital opening usually with disks each side 21
Epimera of female in four groups 22
21. Apical joints of leg I normal ..... *Hygrobates.*
Fifth and sixth joints of leg I curved ..... *Atractides.*
22. Genital opening with three disks each side 23
Genital opening with more than three disks each side 25
23. Second joint of palpus with spine beneath ..... *Tyrrellia.*
Second joint of palpus without spine beneath 24
24. Legs and palpi extremely long ..... *Hydrochoreutes.*
Legs and palpi rather short, male with middle joint of hind legs enlarged. *Acercus.*
25. Legs I and II with spirally ringed bristles ..... *Neumania.*
Legs without such bristles 26
26. Genital opening at tip of body 27
Genital opening much before the tip 28
27. Without swimming hairs on legs; fourth joint of palpus without three spurs below; genital area large ..... *Feltria.*
With a few swimming hairs; fourth joint of palpus with three spurs, or papillæ, below; genital area smaller ..... *Atax.*
28. Hind epimera with a pointed projection below; palpi larger than leg I. *Najadicola.*
Hind epimera without a projection; palpi smaller, and ending in two or three small claws; the fourth has two papillæ below ..... *Piona.*
29. Median eye in the soft skin ..... *Eupatra.*
Median eye on a plate ..... *Hydryphantes.*

The immature forms are known in many genera and these may be tabulated as follows:

1. Coxæ united into a large plate each side leaving only a narrow groove between them 7
Coxæ not united into a large plate leaving only a narrow median line; beak large and prominent; palpi of three or four joints usually extended; no dorsal shields 2
2. Coxæ I and II partly united, palpi curved under beak ..... *Eylais.*
Coxæ I and II separate, palpi extended 3
3. Beak nearly as long and as broad as body; tarsi subtruncate at tips ... *Hydrachna.*
Beak only about one-half length of body; tarsi tapering to fine point 4
4. A median pore between eyes 5
No median pore between eyes 6
5. Beak divided by median line for entire length ..... *Hydryphantes.*
Beak divided only on apical half ..... *Thyas.*
6. Legs with six joints beyond coxæ ..... *Limnochares.*
Legs with apparently but five joints beyond coxæ ..... *Diplodontus.*
7. Hind legs fully three times as far from second as second from first; hind legs with fifth joint from tip several times as long as broad; body usually elongate ..... *Limnesia.*
Hind legs but little farther from second than second from the first pair 8

8. On venter the groove from coxæ II reaches the median groove near tip of body ..... *Frontipoda.*
   This groove (when present) reaches median groove near or before middle ... 9
9. The grooves from coxæ II and III are both rudimentary and neither reach near the median groove ..... *Hygrobates, Atractides.*
   Groove from coxæ II reaches median groove 10
10. Groove from coxæ III also plainly reaches median groove 11
    Groove from coxæ III does not reach median groove 12
11. Beak with palpi prominent from above; legs arise from margin ..... *Arrenurus.*
    Beak with palpi hidden under front of body; legs arise well under body. *Midea, Mideopsis.*
12. Median groove with a transverse line or interruptions near tip 13
    No such interruptions on median groove 16
13. Groove from coxæ III reaches one-half way to median groove 14
    Groove from coxæ III does not reach one-half way to median groove 15
14. Median groove with line just before tip ..... *Wettina.*
    Median groove with two interruptions, or at least one much before tip. *Laminipes, Hygrochoreutes.*
15. In hind legs fifth joint from tip is very distinct ..... *Atax, Neumania.*
    In hind legs fifth joint from tip is minute ..... *Tiphys.*
16. Groove from coxæ III reaches one-half way to median groove 17
    Groove from coxæ III rudimentary 19
17. Legs arise from well under body ..... *Brachypoda.*
    Legs arise near margin 18
18. Body nearly circular ..... *Teutonia.*
    Body elongate ..... *Curvipes.*
19. A short median process at tip of body ..... *Lebertia.*
    No such process ..... *Axonopsis.*

FIG. 78.—*Arrenurus* sp.: Palpus. (Author's illustration.)

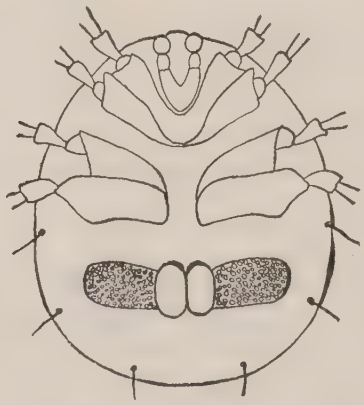


FIG. 79.—*Arrenurus* sp.: Female from below. (Author's illustration.)

FIG. 80.—Larva of a hydrachnid. (Original.)

The genus *Limnochares* (figs. 72, 73) is practically an aquatic trombidian; the body is of the same shape, and red in color. It can not swim, but creeps over the mud and plants under water. The young are parasitic on water skaters (Gerridæ). Our species is very like the European.

We have three species of *Eylais* (figs. 74, 75). They are distinguished by having four simple eyes situate close together on a plate near the median line. They are most frequently found in ponds, and a larva of this genus has been found on mosquitoes. The genus *Thyas* (figs. 84, 85, 86), of which we have a few species, has no swimming hairs on the legs, and beside the lateral eyes there is a median eye in front. About 20 species of *Arrenurus* (figs. 77, 78, 79) have been described from North America; and doubtless many more occur. They are often green in color and have a chitinous dorsum, which, in the male, has a circular furrow open behind. The males have the body extended behind, forming a median petiolus. They live most commonly in lakes and ponds. All come from Northern States and none from the far West. *Krendowskia* and *Axonopsis* are each represented by one species. *Albia* is similar to *Axonopsis* and the one European species also occurs in the Northern United States.

In *Aturus* the epimeral plate covers nearly the entire ventral surface; one species is known from a small river in Canada. Of *Xystonotus* and *Mideopsis* but one species is known in each. The latter is also a common European water mite.

FIG. 81.—Larva of an *Hydrachna* attached to leg of an insect; nymph inside. (Author's illustration.)

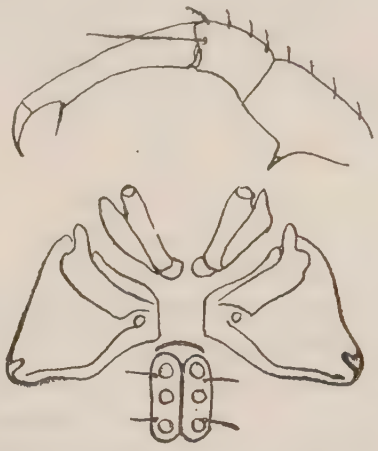


FIG. 82.—*Limnesia* sp.: Palpus and coxal plates. (Author's illustration.)

The species of *Sperchon* (figs. 90, 91) are often found in cold and rapid mountain streams. Three species are known from Canada. They have the palpi enlarged at

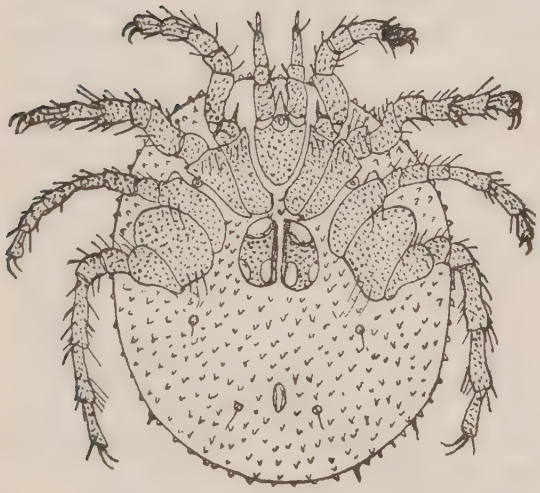


FIG. 83.—*Tyrrellia circularis*. (Author's illustration.)

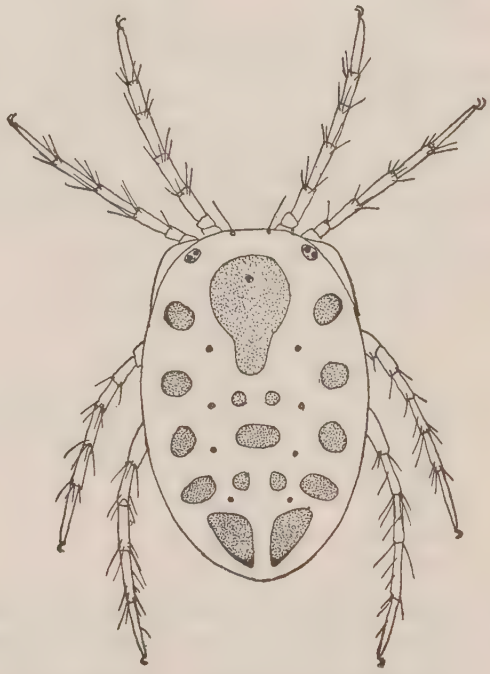


FIG. 84.—*Thyas* sp. (Original.)

base, and the second joint bears a strong spur below. The sucking disks each side of the genital opening are nearly concealed by lateral flaps. The legs have no special swimming hairs, and coxæ III and IV are widely separated from I and II.

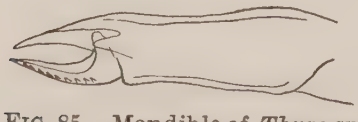


FIG. 85.—Mandible of *Thyas* sp. (Original.)

FIG. 86.—Palpus of *Thyas* sp. (Original.)

Limnesia (fig. 82) is a large genus. Three species have been recorded from Canada, two of them European. They have a soft body; the hind legs are well provided with swimming hairs, and the fourth tarsus lacks the claws, but is provided with a bristle

at tip. The palpi have the basal joints enlarged and often with a spur below. They usually occur in lakes.

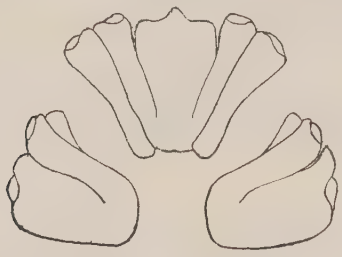


FIG. 87.—Coxal plates of *Hygrobates*. (Original.)

FIG. 88.—Palpus of *Hygrobates*. (Original.)

Of *Atractides* (fig. 89) one European species has been recorded from Canada. The palpi are close together on a short elevation, the fourth joint rather swollen and bristly above; there are shields on the dorsum of the body.

FIG. 89.—Palpus of *Atractides*. (Original.)

Lebertia (fig. 92) (and its subgenera) has many species in Europe, one of which has been recorded from Canada, but the American form has much longer hairs than the European specimens.

Tyrrellia (fig. 83) was based on a round-bodied, short-legged species from Canada; the palpi are rather short, and the second joint has a spine beneath.

To *Thyopsis* (near *Thyas*, but without median eye) belongs a remarkable species, *T. cancellata* Koenike. The entire dorsum is densely reticulate, the central part with a large and heavy reticulation.

Koenikea is represented by one species widely distributed in the northern parts of our country. The species of *Hygrobates* (figs. 87, 88) have soft bodies, the slender legs

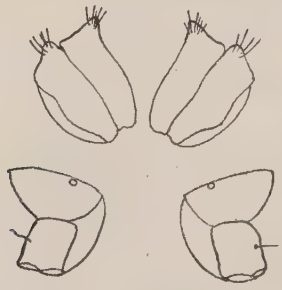


FIG. 90.—Coxal plates of *Sperchon*. (Original.)

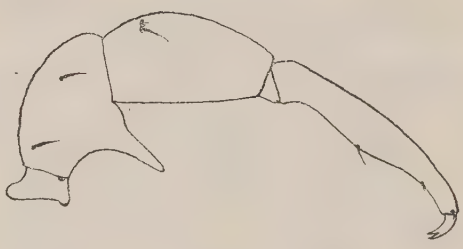


FIG. 91.—Palpus of *Sperchon*. (Original.)

destitute of true swimming hairs, the palpi have no tooth below, and the epimera form three plates. There are three sucking disks each side of the genital orifice. Four species are known from small rivers in Canada.

Atax (figs. 95, 96, 97, 98) is one of the largest genera, and Dr. Wolcott has worked out some 12 species, and another has since been added from Texas. The genital opening is situate at the tip of body, and the sucking disks each side are 10 or more in number. The legs have swimming hairs, and the first pair is thicker than usual. The palpi (fig. 98) are enlarged at base, and the fourth joint bears three papillæ or spurs below. Most of the species occur, for at least a time, in certain fresh-water mussels, particularly of the genera *Unio* and *Anodonta*. They are found in the mantle folds or gills of the mussel, and feed on the minute animals drawn in by the mussel.

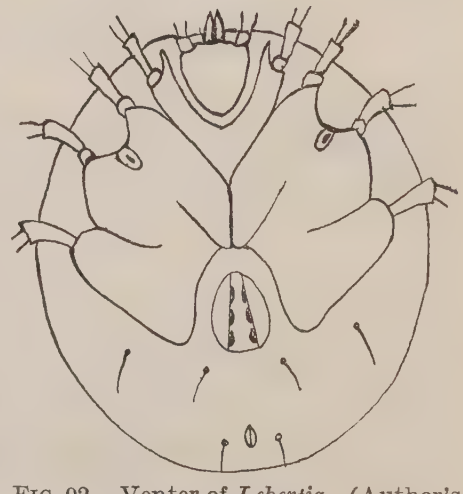


FIG. 92.—Venter of *Lebertia*. (Author's illustration.)

The genus *Neumania* is closely allied to *Atax*, but peculiar on account of the spirally ringed bristles on legs I and II.

The genus *Piona* (figs. 93, 94) (*Curvipes*) is also a large genus, and about 19 species are now known in North America. In appearance they are similar to *Atax*. They occur chiefly in lakes and ponds. The fourth joint of the palpus usually has two papillæ beneath, and the legs are well provided with swimming hairs. The genital aperture is much in front of the hind margin, and each side of it are a great number of sucking disks, often of two sizes. In the males of some species one or two joints of the hind legs are enlarged or produced at the tip.

FIG. 93.—*Piona* sp., and palpus above. (Author's illustration.)

FIG. 94.—Larva of *Piona*. (Author's illustration.

The typical genus, *Hydrachna*,[1] includes a number of globose mites of moderate size, the legs with swimming hairs, the palpi slender, with the last joint very short, similar to *Trombidium*.

Feltria is similar in appearance to *Atax*, but there is a large plate on each side of the apex of the venter bearing many disks. In the male these plates are united. Some of the species occur in wet moss, but many in mountain streams.

FIG. 95.—*Atax* sp. (Author's illustration.)

FIG. 96.—Coxal plates of *Atax*. (Author's illustration.)

In *Hydrochoreutes* the legs are very long, sometimes three times as long as the body, which often protrudes considerably in front of the mouth parts. The genital apparatus of the male forms a slender terminal petiole; the female is very much larger than the male.

[1] The type of *Hydrachna* was fixed by Latreille in 1810 (Consid. gen.) as *H. geographicum* Müller. He did not give type to *Hydrachna* (nor any old genus) in his Précis (1796).

In *Oxus* the body is about twice as long as broad, and the venter is mostly occupied by the great epimeral plate, which is emarginate in the middle behind for the genital opening. The legs are all crowded up near the front of the body. *Frontipoda* is similar to *Oxus*.

A number of water mites were described by Haldeman in 1842 in a new genus *Unionicola*. The characters were all in the colors, so it is possible that all or most of them are variations of the common *Atax ypsilophorus* Bonz. He also described several

FIG. 97.—Tarsal claw of *Atax*. (Original.)

FIG. 98.—Palpus of *Atax*. (Original.)

Hydrachna, but these also have not been placed in modern genera. Many genera have been made for exotic species. The African fauna has been explored more thoroughly than the others, but most of the forms are similar to the European. *Bargena* is remarkable on account of its large, median ventral furrow.

FAMILY HALACARIDÆ.

This is a small family of marine mites. They have a leathery skin, frequently granulate or striate, but commonly destitute of bristles. Sometimes there are coriaceous plates or shields. The body usually shows the division into cephalothorax and abdomen, both above and below. The rostrum is often quite prominent, sometimes as large as in the Bdellidæ. The cephalothorax usually has three eye-spots, one being located on the middle in front. The palpi are three or four jointed, the last article sharp-pointed at tip. The mandibles are rather prominent and end in a single straight or recurved claw. The legs are moderately long, rather widely separate at base, lateral or sublateral in origin, and end in two claws (fig. 99). They bear a few scattered bristles and sometimes dense plumes of fine hair. Some species have lamellæ on their femora, similar to those in certain Oribatidæ, and the joints are swollen near tip as in many Oribatidæ. The genital opening is quite large and far back; the anus is small and at the tip of the abdomen. These mites have no tracheæ, but do not appear to be related to other atracheate acarians, but rather to the Bdellidæ and Oribatidæ. It is perhaps not a natural family, but derived from several groups. The Halacaridæ are found crawling slowly over algæ, frequently in shallow water, but some have been dredged at considerable depths. The adults are free and feed on diatoms and other minute vegetation. The young of some forms feed on the eggs of copepods, which often are attached to various animals. One (*Halixodes*) is known to occur on a *Chiton*. They are from less than 0.5 to 2 mm. in length and their colors depend largely on the nature of their food. The young have the general appearance of the adults, and nymphs sometimes possess rudimentary genital organs. The legs of the nymphs have often one less joint than in the adults. The ovipositor is a fleshy exsertile organ tipped with several pairs of bristles. But little is known of their life history. The eggs appear to be few in number, one species having from 8 to 12. Some species apparently deposit eggs in spring, and during the summer one finds only immature specimens, the adults appearing in the fall or early winter; in other species the adults and young may be taken at any time. The same species may occur in deep water and near the shore,

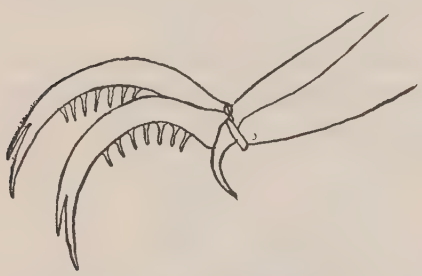


FIG. 99.—Claws of *Halacarus*. (Author's illustration.)

and 7 species have been taken at a depth of over 3,500 feet. They have been found in nearly all seas, and nearly 100 species are now known. The forms along the coasts of North America have not been studied. The principal genera may be tabulated as below:

1. Rostrum elongate and constricted at base 2
   Rostrum not constricted at base 3
2. Palpi apparently three-jointed, separate ..... *Scaptognathus.*
   Palpi four-jointed, connate at base ..... *Trouessartella.*
3. Rostrum elongate, palpi separated at base 5
   Rostrum very short, triangular 4
4. Palpi separated at base ..... *Rhombognathus.*
   Palpi connate at base ..... *Simognathus.*
5. Palpi apparently but three-jointed ..... *Coloboceras.*
   Palpi plainly four-jointed 6
6. Third joint of palpus nearly as long as fourth ..... *Agaue.*
   Third joint of palpus much shorter than fourth ..... *Halacarus.*

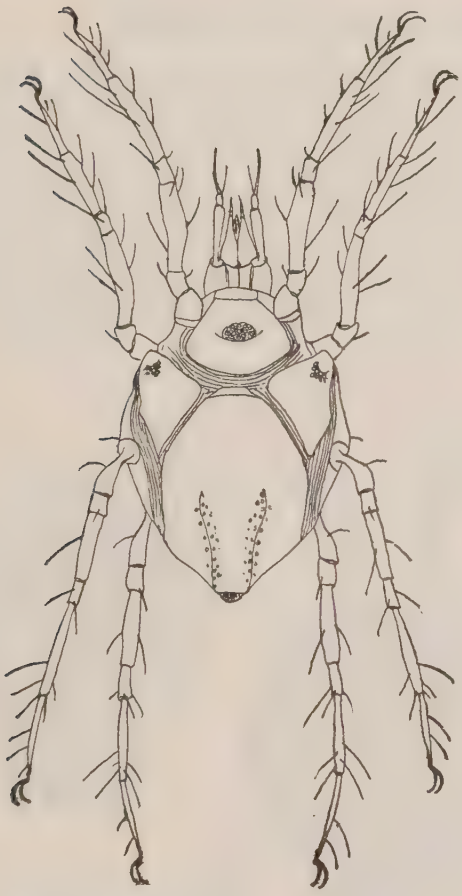


FIG. 100.—*Halacarus* sp. (Author's illustration.)

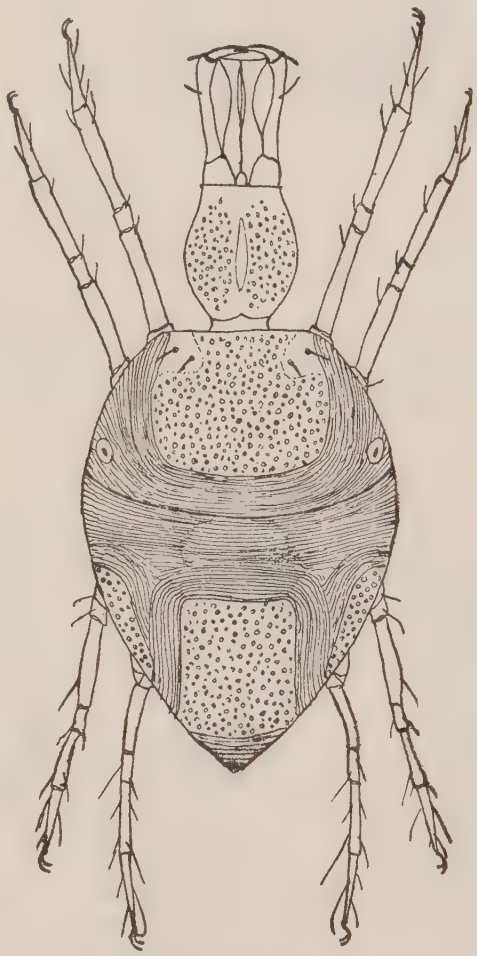


FIG. 101.—*Scaptognathus* sp. (After Trouessart.)

Most of the known species come from the French coasts of the Atlantic Ocean, several are known from the Antarctic, and one was described from fresh water. Doubtless as they are more collected the family will be of considerable size. *Halacarus* (fig. 100), the largest genus, contains over 50 species, several of which bear some resemblance to *Scutovertex* in the Oribatidæ. Most of them are marked with brown, reddish, or black. Dr. E. Trouessart, of Paris, and Dr. Lohmann, of Berlin, have published very largely upon them and revised the family. Packard described, under the name of *Thalassarachna verrilli*, a species of *Halacarus* from the coast of Maine, found on algæ. Mr. Hall has described two species of *Copidognathus* (a subgenus of *Halacarus*) from the California coast.

Scaptognathus (fig. 101) and *Simognathus* (fig. 102) have each a number of species, neither with much resemblance to the true Halacaridæ. *Leptognathus* is similar to *Halacarus*, but the palpi are situated close together at the apex of a prominent beak, and the last joint of the palpus is not so slender. The species occur not far from shore. *Acaromantis* is similar to *Simognathus*, but the first pair of legs is destitute of claws, the very short tarsus ending in a number of hairs. *Atelopsalis* is based on an abyssal species similar to *Scaptognathus*, but the rostrum is small and short.

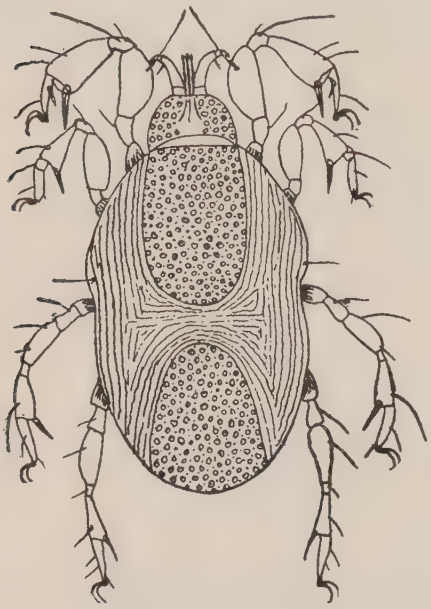


FIG. 102.—*Simognathus* sp. (Original.)

Of *Agaue* about a dozen species are known. Most of them occur not far from shore. They have the first pair of legs much thicker than the second pair. *Rhombognathus* also includes about a dozen species, most of which occur on algæ in the littoral region, but one was described from fresh water in England. They are much smaller than the ordinary *Halacarus*, usually only a third of a millimeter long.

Superfamily IXODOIDEA.

The members of this group, commonly known as ticks, are of all acarians the most familiar to most people. They are all mites of considerable size; even the young or "seed ticks" are visible to the naked eye, while a full-grown engorged female may be more than one-half inch long. Their abundance on many of the domestic animals and occasional occurrence on man have rendered them well-known objects of disgust in every clime.

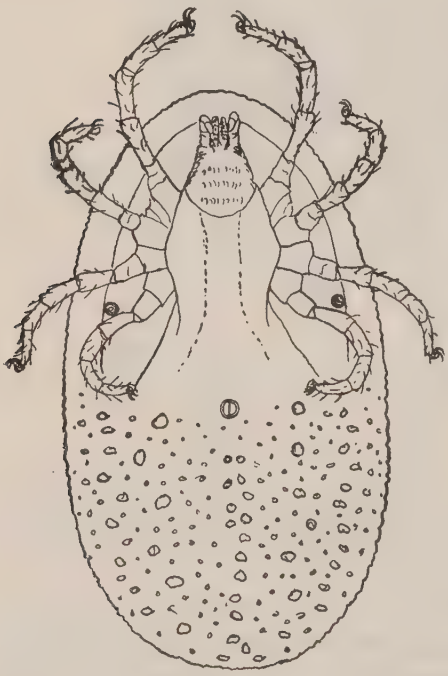


FIG. 103.—*Argas miniatus*, from below. (Author's illustration.)

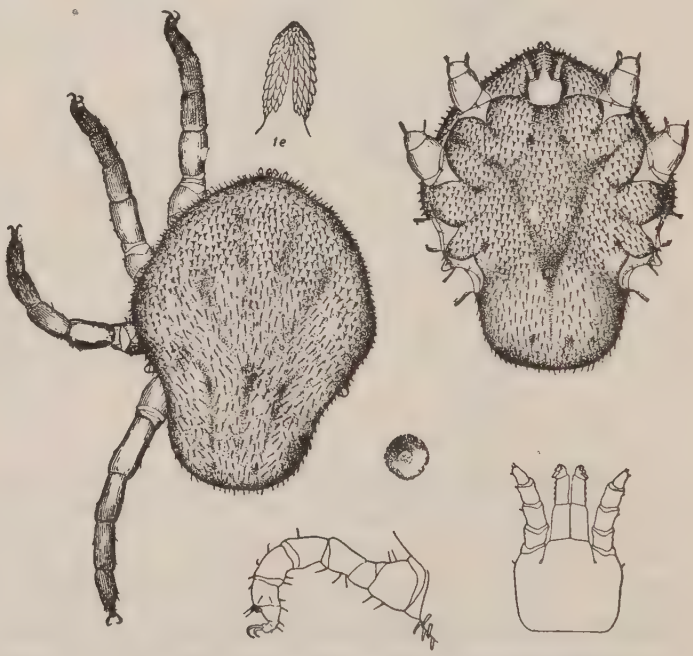


FIG. 104.—*Otobius megnini:* Nymphal form and details. (From Marx).

The body is covered by a tough, leathery skin, which in the female becomes greatly distended as she engorges herself with the blood of the host. Before distention the tick is of a somewhat triangular outline, flat, with prominent, slender legs, and a beaklike rostrum in front. When the female becomes swollen these structures may be hardly noticeable, and the whole creature looks like some large seed or bean. In

most of the forms there is on the front part of the dorsum a corneous shield known as the scutum. In the male this scutum covers the greater part of the body, but in the female only a small part in front. Articulated to the anterior margin of this scutum, and usually within a slight emargination, is a small subtriangular piece, called the capitulum, or head. This capitulum bears the palpi, the mandibles, the mandibular sheaths, and the hypostome. The last three organs together form the proboscis, or haustellum. The hypostome (fig. 107) is a median piece (really of two pieces) bearing beneath many recurved teeth, or denticles. The more basal of these denticles are situated in rows, and the number of these rows is used in the differentiation of species, but is subject to some variation. At the tips of the mandibles are two or three processes, known as the apophyses; these have also been used in specific classification, but also are known to be inconstant. The hypostome and mandibles are inserted into the host when the tick feeds, and so firmly do the recurved teeth of the hypostome hold that if one tries to remove the tick by force the body may be torn from the attached capitulum.

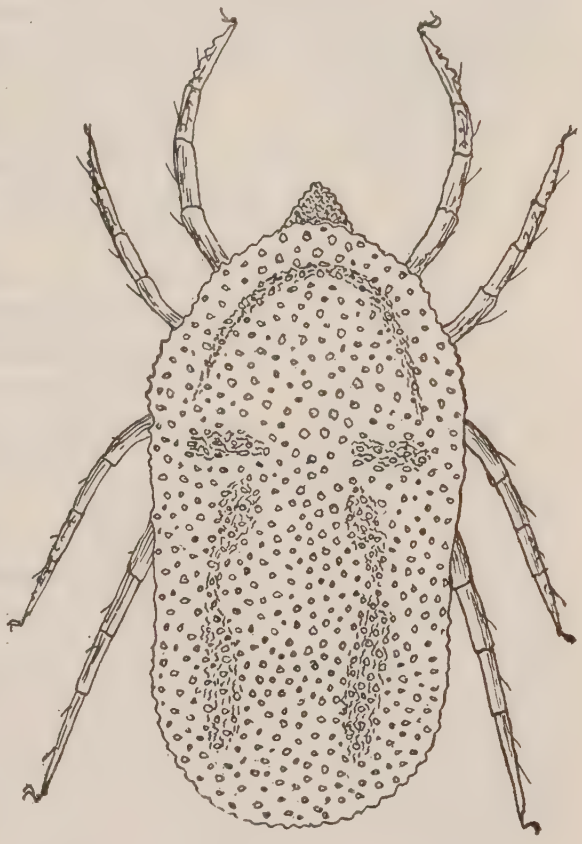


FIG. 105.—*Ornithodoros turicata.* (Original.)

The palpi are inserted at the sides of the mouth parts and are of four joints, but commonly one sees only two, for the basal joint is short and broad, and the apical is very small and often situated in a depression near the tip of the third joint. The palpi are usually somewhat concave on the side toward the mouth parts, so that they may sheath these parts. The comparative length of the second and third joints of the palpi give useful characters in separating the genera of ticks.

FIG. 106.—Ventral furrows: *a, Ixodes; b, Dermacentor.* (Original.)

On the dorsum of the capitulum of adult female ticks are two depressed, pitted areas known as the porose areas. No one has yet determined their function. All female ticks of the family Ixodidæ which do not have these organs fully exposed are immature. Various species, and even genera, have been based on immature forms, owing to a failure to recognize this point. The genera *Phauloixodes*, *Herpetobia*, *Sarconyssus*, and *Gonixodes* are of this class. The scutum or shield is usually irregularly hexagonal in shape. On each lateral margin is a pale eyelike spot or ocellus; in some genera there are no eyes. The posterior margin of the body in most forms is marked by a number (8 to 10) of short impressed furrows, which outline a series of lobes or festoons; these are more distinct in the male than in the female, and when the latter is distended with blood they are barely visible. On the under side, or venter, of the body there are two median apertures. The anterior one is not far from the beak and is the genital pore; the posterior one is toward the tip of the body and is the anus. In many forms there is a curved groove behind the anus, and from it a median furrow extends toward

the tip of the body, while in other species there is a curved groove in front of the anus, and reaching back each side toward the margin of the body. In all forms there is a lateral groove on each side reaching forward to the genital pore. In the males of several genera there are one or two corneous, triangular plates, known as the anal plates, each side of the anus. Sometimes the abdomen terminates in a short median process or tail.

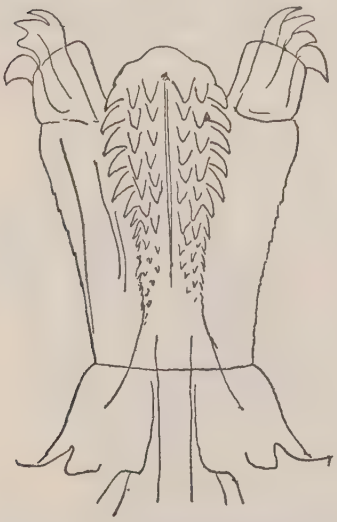


FIG. 107.— Hypostome and mandibles of a tick. (Original.)

The legs arise on each side on the anterior part of the venter. The coxæ are sometimes close together, sometimes more widely separate. The legs are usually slender, subequal in length, but the fourth pair is rather the longest, and sometimes larger than the others. Each is composed of at least six joints, as follows, from base outward; coxa, trochanter, femur, tibia, metatarsus, and tarsus. The latter is commonly more or less definitely divided into two parts. At the tip of the tarsus is a pair of large claws (fig. 112) situated on a rather long pedicel, and between them is a pulvillus. On the upper surface of tarsus I is a pit covered by a membrane; this is known as Haller's organ, in honor of its discoverer, and is supposed to be an organ of audition, but more probably to recognize the approach of a host. One or more of the coxæ are armed behind by spinelike processes or teeth. In the males of some species the hind coxæ are greatly enlarged. Above and usually slightly behind the hind coxæ are the stigmal plates (fig. 108), containing near their centers the stigmal orifices or spiracles. Each plate is a corneous piece, the surface of which is marked by granules of smaller or larger size. The shape and sculpture of the stigmal plate is quite constant in each species, but differs in the sexes.

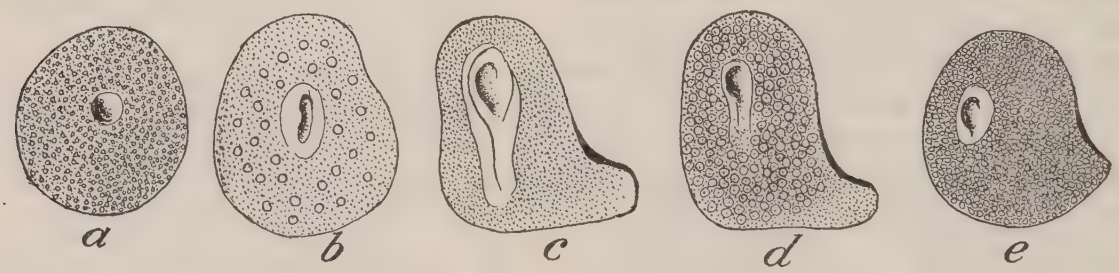


FIG. 108.—Stigmal plates of female ticks: *a*, *Ixodes*; *b*, *Margaropus*; *c*, *Amblyomma*; *d*, *Dermacentor*; *e*, *Haemaphysalis*. (Original.)

In some genera there are on the dorsum, near the middle, a pair of small circular or oval plates, called the dorso-submedian porose plates; no one has yet discovered their use. Ticks are often dull colored, but some forms are brightly mottled with brown, white, yellow, or red. However, each species has a characteristic shade of color, which, when once known, helps in field identification. In some forms the contents of the intestine show through so that the apparent markings are irregular and variable.

Ticks are parasitic during the greater part of their life; most of them, however, leave the host to molt, and all to deposit eggs. Mammals are the ordinary hosts, but birds, reptiles, and batrachians are also infested, and two species of ticks have been taken from insects. Many of them show a decided preference for a certain animal, but a number of the common species have been found on a great variety of hosts. Some ticks have apparently changed their host; for example, the Texas-fever tick, now chiefly found on cattle, originally infested deer, and possibly bison. In sucking the blood of their hosts the ticks, unless extremely numerous, do but slight harm, but several of

them have been shown to transmit the germs of some disease, so that they become, in many cases, economic pests of prime importance. The losses caused by ticks are of enormous extent. The damage done by the cattle tick follows not only from the transmission of disease, but sometimes also from the loss of blood caused by heavy infestation and greater susceptibility to attacks of the screw worm. Besides, there is a quarantine inspection of cattle which restricts the shipping and importation of cattle, so that from all sources the loss is figured at $100,000,000 each year.

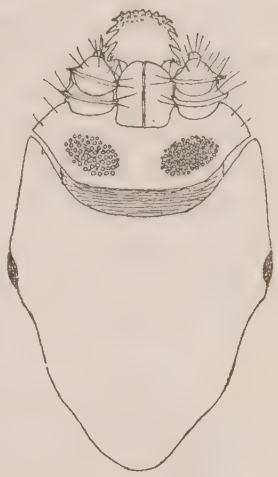


FIG. 109.—Shield of *Margaropus annulatus*, female. (Original.)

Considering the losses from the fowl tick, spinose ear tick, spotted-fever tick, and damage by ticks in general, it is probably not too much to say that ticks cost our country $150,000,000 a year.

Frequently an animal has more than one species of ticks upon it. In such cases the ticks are usually of different genera; thus *Margaropus*, *Dermacentor*, and *Amblyomma*, or *Ixodes* and *Dermacentor*, may be associated on the same host. In some cases, as *Ixodes*, but few specimens occur on one host, while in other cases, *Margaropus* and *Rhipicephalus*, hundreds or even thousands attack one animal. As a result of her bloodthirsty nature the female tick becomes enormously distended, and is then in a mature condition. The male tick does not enlarge, and doubtless does not feed to such an extent as his mate. The engorgement of the female produces a characteristic shape to the body in each species; thus a *Dermacentor* engorged is more elongate than an engorged *Ixodes*. In some cases complete engorgement depends upon fertilization.

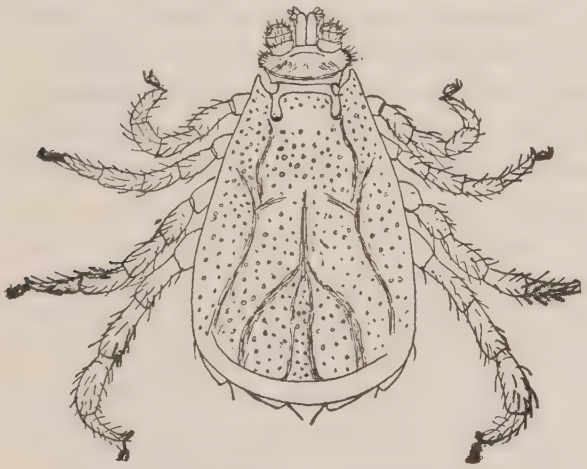


FIG. 110.—*Margaropus annulatus*, male. (Author's illustration.)

The life history of ticks has been investigated by many authors, notably Curtice, Morgan, Lounsbury, and Hunter, Bishopp, and Hooker. The true Ixodidæ engorge but once in adult life, oviposit, and then die. The Argasidæ may engorge several times, depositing after each engorgement. In all cases the female tick drops to the ground to deposit her eggs. These are usually placed upon the surface of the soil or just beneath it. They form an elongate mass in front of the tick, and may be as many as 1,000 to 20,000 in number. The number probably varies considerably, as the cattle tick deposits from 2,000 to 4,000. Several other ticks have egg-laying records of over 2,000, and Morgan has recorded 6,519 eggs for an *Amblyomma americanum* Linn. and Hooker 11,265 for *Amblyomma maculatum* Koch, while two species of *Dermacentor* have records of above 7,000 eggs each. The Argasidæ, however, deposit fewer eggs, and these are placed in batches of 20 to 50 eggs each. When the mother tick is about to deposit eggs she bends the capitulum downward toward the genital aperture; the membrane between the capitulum and scutum is thus exposed and bulges out till it extends over the capitulum in the form of two lobes. The ovipositor is extruded until it comes in contact with the swollen membrane; it is then withdrawn, leaving the egg

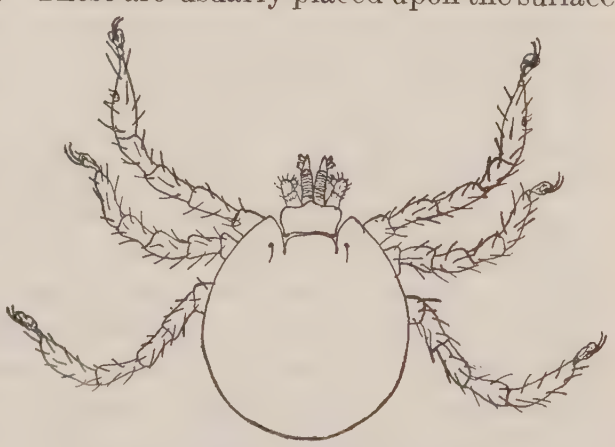


FIG. 111.—Larva of *Margaropus annulatus*. (Author's illustration.)

adhering to the membrane, which, alternately receding and bulging out, rolls the egg back and forth on the capitulum so that it is completely covered by a viscid substance secreted by numerous minute glands in the membrane. This operation is repeated for each egg, the parent resting occasionally. Several hundred eggs may be laid in one day, and as the eggs may number 3,000 or 4,000, it takes several days for the deposition of the entire mass.

This curious method of oviposition was first observed by Prof. Gené in 1844, and has been confirmed by many later observers. The period of incubation varies according to the temperature, in some cases occupying only about three weeks, but usually a longer period. Eggs deposited in the fall will not hatch till the following spring.

The young ticks, known as "seed ticks," often remain clustered for several days and then ascend the nearest support of grass or herb and patiently await the coming of some animal. Delay and disappointment must often end in starvation and death. The seed ticks, however, are able to endure long fasts, and many finally secure an attachment to some animal. After a few days of feeding the young tick becomes distended with blood and drops to the ground. Here it seeks a hiding place and rests from one to several weeks, during which time there are many changes in its internal anatomy. Finally the skin splits and from the six-legged larva there issues the eight-footed nymph. Climbing a plant, it awaits the passing of some suitable animal, and, when attached, feeds, and falls off again to molt; this time to the adult condition. It again waits for a host, and finding one, feeds and starts the life cycle anew. The Texas-fever tick, its allies, and a few other species do not drop off for molting, but cast the skin while on the host. This enables a more rapid increase in the species, and not as many die from failure to find a host. Several other ticks pass the first molt on the host, but drop for the second. When the nymph drops it may be several months before it transforms, and the quiescent period is usually longer than in the larval transformation. Ticks do not always leave upon the death of the host, but often die attached to the animal. Temperature and moisture are the principal elements influencing their life, and most of them prefer a dry, hot climate. Two chalcid parasites have been bred from ticks, and a number of birds sometimes feed upon them. Chance plays a leading part in their life. If the thousands of eggs laid by one female were to mature, in a few generations one pair would be the parents of billions of ticks. The number of ticks in nature remains about the same year after year, so it is evident that only a few of the possible millions ever reach maturity.

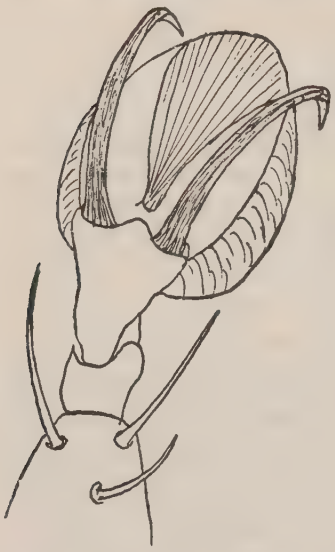


FIG. 112.—Claws of *Margaropus annulatus*. (Author's illustration.)

In the true ticks there is a considerable difference between the sexes. In the male the dorsal shield covers the entire dorsum, whereas in the female there is always an exposed portion behind the shield. In several genera the male has corneous shields near the anus, and in some cases the hind pair of legs are enlarged in the males; the porose areas are found only in the females. The males and females feed side by side, but the younger stages are often restricted to a different part of the host or to a different host than that attacked by the adults. In some cases two years may be required for a tick to become mature; in others there are several generations a year; in several species the young and adults are found on the host at the same time. Ticks have been known to remain on a host for over 200 days, but in many cases life is shorter. Africa is the home of ticks. Nearly all of the known genera occur there and more species than on any other continent. Several species occur quite far north, but as a whole ticks are particularly tropical animals.

Our country has a number of species similar to the European ones, but in the presence of *Amblyomma* and the great abundance of *Dermacentor* our ixodid fauna differs

radically from that of Europe. About 50 different kinds of ticks are now known from the United States, and several others will yet be discovered in the genus *Ixodes*. A number of these, however, are found only in the extreme southern parts of our country. In most places it is possible to find 5 or 6 species of ticks.

Dr. George Neumann, of Toulouse, France, is the great authority on ticks, and he has described fully half of the 400 known species.

The internal anatomy of the Ixodidæ has been examined by Heller (1848), by Pagenstecher (1861), and recently by Nordenskiöld, Samson, and others. The pharynx soon contracts into a slender œsophagus, which, as usual, passes through the "brain" and into the stomach. The latter is not very large, but has several diverticula or cæca, some in front, and usually four large ones behind and a longer one on each side. The color of the food in the cæca often shows through the integument, so that the same species at different times exhibits different markings on the body. Upon this basis the earlier authors often described one species under several names. The intestine is short and straight, enlarging somewhat before the anus. The breathing apertures or spiracles open into a larger sac, which often divides into a host of small tracheæ that spread out in the body cavity. In the anterior part of the body there are two large, botryoidal salivary glands, opening through a duct each side of the mouth. The female genital organs consist of two elongate ovaries, each with a slender oviduct, which unite shortly before the vulva. The male organs consist of the two slender testes, each emptying into a large median sac, from which a slender duct leads to the opening. In mating, the ventral surfaces are apposed; the male introduces his mouth parts into the vulva of the female for a short time; then the apertures are apposed and the spermatophore issues from the male and is pushed into the vulva of the female by his hypostome. A secretion of the liquid from the coxal glands of the male probably assists the process. The male, after becoming mature, usually feeds before mating.

FIG. 113.—Egg of *Margaropus annulatus*. (Author's illustration.)

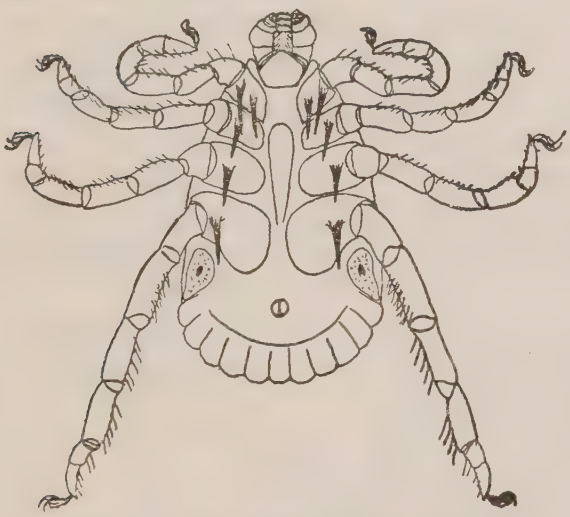


FIG. 114.—*Dermacentor variabilis:* Male from below. (Author's illustration.)

In recent years ticks have become prominent from the connection of certain species with certain diseases, so that many writers and many publications are appearing and the family is becoming well known. It has long been known to cattle raisers in the Southern States that cattle dying from Texas or Spanish fever were infested with ticks, and it was therefore quite natural for them to attribute the disease to the tick. Veterinarians, however, did not believe it, and Gamgee, in his extensive report on the diseases of cattle (1869), argued against the supposed connection. In 1880 a report on the louping-ill of sheep by a committee of the Teviotdale Farmer's Club in Scotland brought out the fact that *Ixodes* were very abundant on all afflicted animals and suggested that the ticks were in some way responsible for the disease. In 1890 Dr. P. Paquin considered the tick as an agent in transmission of cattle fever, but had little actual evidence. On the basis of "He discovers who proves" the credit belongs to Kilborne and Smith. In 1889 Dr. L. Kilborne thought to test the popular theory and became convinced that the cattle tick was necessary in the transmission of the disease. Later he, with Dr. Theobald Smith, proved that the tick was an intermediary host of the blood parasite causing the disease, and Dr. Smith described the parasite as *Pyrosoma bigeminum*, now *Babesia*. Southern cattle accustomed to tick

infestation from birth become immune to the disease, but if not raised in tick-infested fields they are as susceptible to the disease as northern cattle.

Texas fever occurs in most parts of the world, and *Margaropus* is the disseminator. Coincident with the discoveries connecting mosquitoes and other insects with disease came similar discoveries in regard to ticks. These have come so fast and have been so novel and astonishing that ticks have become one of the most prominent economic groups.

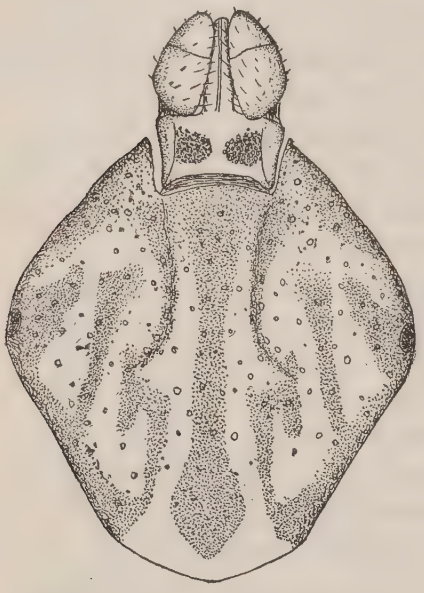


FIG. 115.—Shield of *Dermacentor variabilis*, female. (Original.)

Many of the statements are but suspicions; other discoveries lack confirmation; but several prominent diseases have been definitely connected with certain ticks. In South Africa, Lounsbury has shown that heartwater is transmitted by the "bont tick," *Amblyomma hebraeum* Savigny. Later he has proved that malignant jaundice in dogs is due to the attacks of *Haemaphysalis leachi* Koch, and that African coast fever in cattle is carried by five different species of *Rhipicephalus*. The "moubata bug," *Ornithodoros moubata* Murray, is the inoculating agent of one of the most dangerous diseases of tropical Africa, known as human tick fever, or African relapsing fever. The discovery of the tick's relation to the disease is due to Drs. J. E. Dutton and J. L. Todd.

In our country Dr. H. T. Ricketts connected the Rocky Mountain spotted fever with *Dermacentor venustus* Banks. The *Argas miniatus* Koch, has been shown to transmit spirochætosis in fowls.

Many other diseases are accredited to the bites of ticks. Thus louping-ill in sheep appears to be carried by an *Ixodes;* carceag, a European disease of sheep, is supposedly transmitted by *Rhipicephalus bursa* Neumann; a disease of turtles is laid to *Hyalomma aegyptium* Koch; and this same *Hyalomma* is considered by Laveran to transmit a blood parasite of the python snakes. In Russia *Dermacentor reticulatus* Linn. carries a piroplasmosis of horses. An undetermined Ceylonese tick is the supposed vector of paranghi or "yaws." The tick is a most necessary host in the life history of these parasites, for in some cases (perhaps in all) the sexual conjugation of the parasite is consummated within the body of the tick.

From the known results, it is evident that the power to transmit disease-causing organisms is not confined to any one genus or section of Ixodoidea,[1] but common to all. Moreover, in different countries extremely similar diseases are carried by very different ticks. Therefore the diseases have not originated in the ticks. Most, if not all, of the species now acting as vectors of disease to certain hosts were probably originally confined to other hosts. To their original or natural host they brought no disease. Certain low organisms living in the blood of the host were transmitted by the ticks to other animals of the same species with little or no serious danger. But when a tick containing the blood parasites of one of its natural hosts becomes attached to a new and different kind of host, then the blood parasite in this alien blood may originate a disease. The occasional transference of a tick from one host to another may not be sufficient; but when a species of tick is compelled by the march of civilization and consequent extermination of native animals to adapt itself to another host, a disease may result, provided, of course, that the ticks were commonly infected with a blood parasite of their old host.

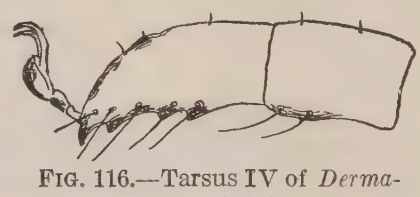


FIG. 116.—Tarsus IV of *Dermacentor*. (Original.)

[1] It has been shown experimentally that the Rocky Mountain spotted fever may be transmitted by several species of ticks of even different genera.

Some writers have elevated the ticks to a position higher than a family or superfamily; usually to a suborder; thus Marx called them Cynorhæstea, and Lahille Arpagostoma, while Koch and others have designated them an order, Ricini. Their relationship to the Parasitoidea is such that they should not rank higher than a superfamily.

The Ixodoidea are readily divided into two families:

No scutum; no ventral shield; mouth parts of adult not prominent from above; no pulvillus to tarsus in adults; stigmal plate between coxæ III and IV.....ARGASIDÆ.
Scutum present; sometimes ventral shields; mouth parts of adult prominent from above; pulvillus to tarsus of both adults and young; stigmal plate behind coxae.....IXODIDÆ.

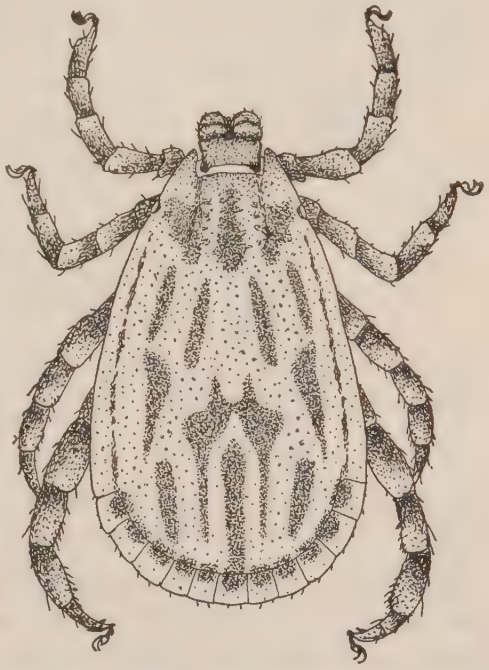


FIG. 117.—*Dermacentor albipictus:* Male. (Original.)

The Argasidæ, containing but few genera, are in some ways intermediate between the true ticks (Ixodidæ) and the Dermanyssidæ. The skin is usually covered with granulations or deeply pitted, and the head and mouth parts are hidden beneath the anterior part of the body. They are nocturnal in habit and feed on the blood of mammals (including man) and birds. Unlike the true ticks, the females of this family do not become so greatly distended with blood. There are three genera and two subgenera in our fauna.

1. Margin of body thin and acute.....*Argas.*
   Margin of body rounded..... 2
2. Body with many short stiff bristles; mouth parts weak and indistinct.....*Otobius.*
   Body without bristles; mouth parts well developed.....*Ornithodoros*

Argas has two subgenera as follows:

1. Body as broad or broader than long.....*Caris.*
   Body much longer than broad.....*Argas.*

Ornithodoros may also be divided as follows:

1. A lateral flap each side of mouth parts.....*Alectorobius.*
   No such flaps.....*Ornithodoros.*

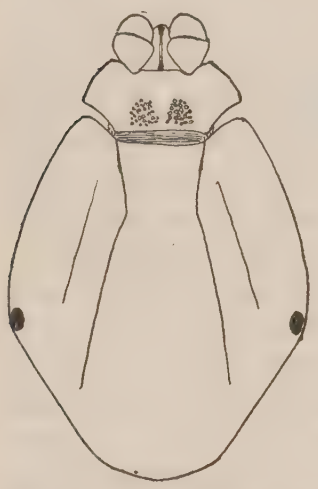


FIG. 118.—Shield of *Rhipicephalus sanguineus,* female. (Original.)

In the female argasids the genital orifice is transverse; in the male it is crescentic. The females may engorge and oviposit several times.

It is to the genus *Argas* that the famous "miana" bug of Persia (*A. persicus* Oken) belongs. It lives in houses, and its puncture was declared by the early travelers in those regions to produce startling results—convulsions, delirium, and even death following its attack. Specimens kept in Europe for experiment have failed to produce these dire consequences, but there is such a wealth of testimony as to the dangerous effect of the bite in Persia that possibly in that country the "miana" bug may at times carry the germs of such disease. The European species *Argas reflexus,* Fabr. commonly infests pigeons, but has been known to attack man; not, however, with serious results. This species has been recorded from our country, but perhaps erroneously, as specimens have not been seen by acarologists. Our common species of this genus, *Argas miniatus* Koch (fig. 103), (*americana* Pack.) is found in the southern parts of the United States from Texas to California, and often does a great deal of injury to poultry. It occurs in other parts of the world, probably

carried on poultry. Chickens, badly infested, droop, refuse to eat, in a few days drop down, and finally die. The tick is red-brown in color, the margins of the body are rather sharp, and above scarred and pitted in a scarcely regular way. It has also been taken on diseased quails in California, and thought to cause the disease.

FIG. 119.—Palpus of *Rhipicephalus*. (Original.)

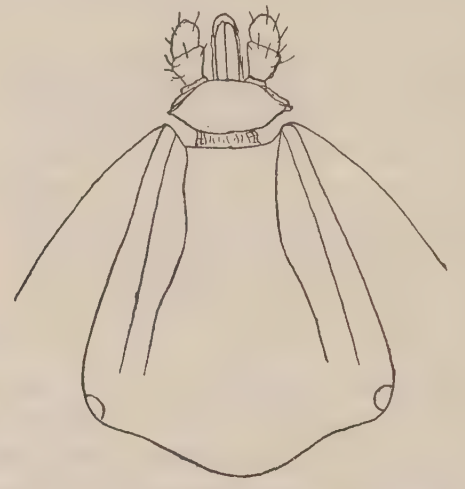


FIG. 120.—Shield of nymph of *Rhipicephalus*. (Original.)

The eggs of the *Argas miniatus* are laid in cracks and crevices of floors, walls, etc. The young larvæ are at first colorless, but after feeding become darker; they may remain on a fowl for 10 days, but usually drop sooner to transform to the nymph; the larvæ usually drop at night, so that the nymph will be near the roosting quarters of the fowls and have no difficulty in finding a host. The adults do not feed so often.

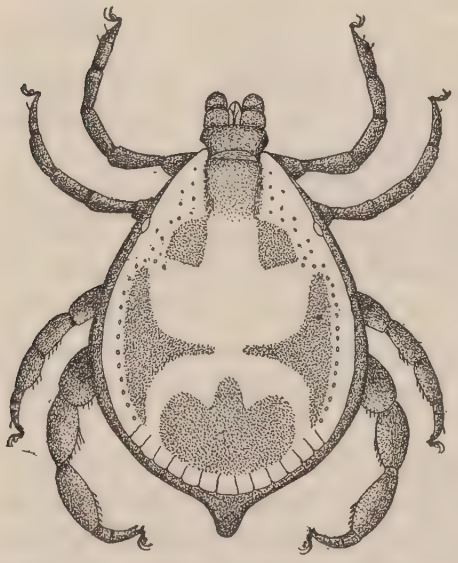


FIG. 121.—*Rhipicephalus pulchellus*: Male. (Original.)

This species, as well as other argasids, can live a long while without food. Unfed specimens have remained alive for over two years. The chicken tick in Brazil transmits a blood parasite (*Spirochaeta marchouxi*) which is usually fatal to poultry, and a similar spirochætosis has been observed in poultry in other countries, produced by the same or a related parasite. Perhaps the best remedy is to spray the inside of the chicken house with kerosene or benzine, then whitewash or dust with carbolated lime, and finally daub the ends of the roosts with coal tar. Isolating the roosts by suspending them on stout wire, or by placing a barrier of cotton waste soaked in oil around each end, will also be helpful.

Two species of *Argas* have the body broader than long. One (*A. vespertilionis* Latr.) occurs on bats in Europe and North Africa. Pocock has revived Latreille's generic name, *Caris*, for this species; the other broad form is *A. transversus* Banks, which occurs on the large tortoises of the Galapagos Islands; they may be considered to represent a subgenus.

The genus *Ornithodoros* includes a number of species distributed throughout the warmer regions of the world. Several species that inhabit houses can inflict a severe bite and are well-known pests in nearly all tropical countries. They can secrete from their coxal glands an alkaline fluid which tends to prevent the coagulation of blood. *O. coriaceus* Koch occurs in California on cattle; it also attacks the herders, its bite causing large swellings that are very painful and remain for a week or more. This species has eyes, or ocelli, each side above coxæ II. It is locally called "pajahuellos."

O. turicata Duges (fig. 105) is found in the southern parts of the United States from Florida to California, and down into Mexico and Central America. It attacks cattle, hogs, and man, as well as various small animals. The popular name, "turicata," is given it by the Mexicans; but from its occurrence in the native houses it is sometimes called the "adobe tick."

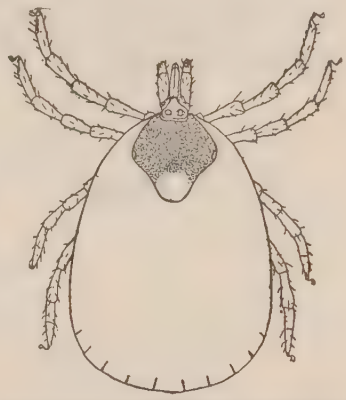


FIG. 122.—*Amblyomma americanum:* Partly engorged female. (Original.)

The "moubata bug" (*Ornithodoros moubata* Murray) is a tropical African species which transmits to man a blood parasite, *Spirochaeta duttoni*, that produces a dangerous fever known as African relapsing fever or "tick fever." The symptoms are severe headache, vomiting, and abdominal pains; there are often five or six relapses, which leave the victim very weak, but the disease is not commonly fatal. The bites of the tick, like others of this genus, are painful, and produce hard raised wheals. If the tick is infected, the fever will begin within 5 or 10 days. The ticks are sometimes not as common in the native huts as elsewhere, and there is some evidence that the natives become immune to their bites. Aged natives are sometimes found upon which the bite will leave scarcely a mark. Wellman states that the bite of the nymphal tick is often more severe than that of the adult. They commonly bite at night, but sometimes in the day. This tick was called "tampan" by Livingstone, who was the first to write about it, and who had experienced its bite. It has many local names, such as "bibo," and "papazé," besides "moubata." In this and the closely allied *O. savignyi* Audouin, the larva upon hatching is very weak and does not feed, but soon becomes quiescent and transforms to the nymph. In 2 or 3 days these are ready to feed, and thereafter increase rapidly in size. The nymph molts several times, and Dönitz claims that the female tick may molt after oviposition. *O.* (*Alectorobius*) *talaje* Guérin occurs in the southern parts of the United States, Mexico, and Central America. It is usually found in old houses, where it attacks people at night, its bite being extremely painful. This species has no humps on any tarsi. Another species, *O.* (*A.*) *capensis* Neum., occurs in South Africa, where it chiefly attacks penguins on the islands near the coast. Other species of *Ornithodoros* occur in Africa and Asia, all of which are feared for the painfulness of their bites. One species, *O. marginatus* Banks, occurs in bat caves in the West Indies. It differs from all other forms in the series of elevated processes around the margin of the body.

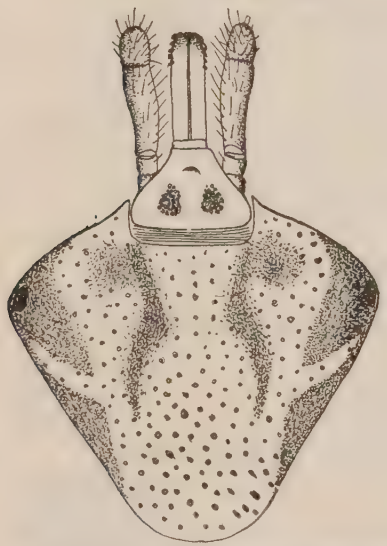


FIG. 123.—Shield of *Amblyomma cajennense*, female. (Original.)

Ctobius megnini Dugès (fig. 104) (formerly *Ornithodoros*) is one of the most remarkable species of the family. It is of a brown or blackish color, and the nymphal stage, which is quite unlike the adult and figured by Marx as *Rhynchoprion spinosum* Marx, is clothed with many stout spines. It occurs in the ears of horses, cattle, sheep, and sometimes man, and is called the "spinose ear tick." It has been known to cause death in cattle. It can be removed by the application of some bland oil, as linseed or olive oil. It is a Mexican species, but occurs in our country as far north as Nebraska. The adult is known to the Mexicans as the "garrapata," and the young are called "pinolias." The nymph sucks enough blood, so that the adult tick does not have to feed, and probably rarely if ever takes nourishment. Its mouth parts are weaker and less armed than in other argasids. The nymph, when full fed, climbs up trees or build-

ings for several feet, molts, mates, and then begins to oviposit, placing her eggs in a crevice. The mother then dies. The larvæ, upon hatching, remain in a bunch until an opportunity for attachment occurs, when they seek the ear of their host. The first molt is passed on the host, and the nymph often remains attached for a long time. The female, if she does not find a mate, may live for at least 18 months. Specimens kept in pill-boxes have produced slight tapping sounds.

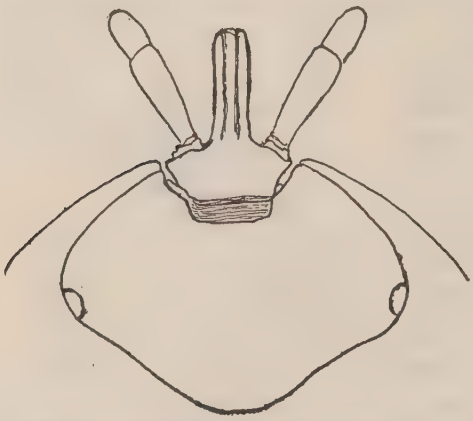


FIG. 124.—Shield of nymph of *Amblyomma*. (Original.)

The Ixodidæ, or true ticks, are represented by a large number of species in tropical countries, but in the temperate regions they are much less common. However, there are about 40 species in the United States, and one of these, the Texas cattle tick, is a pest of prime importance. Various classifications of the Ixodidæ have been presented by a variety of authors, most of whom relied on the comparative length of the palpi as a primary character. This, however, is not sufficiently different to be easily recognized; Lahille based a classification mostly on sexual characters, as the presence and number of ventral plates in the male.

The following arrangement is more satisfactory, and applies also to the nymphs:

1. Venter showing a curved groove (fig. 106) a short distance in front of the anus, and extending back each side to the hind margin; no posterior marginal festoons; stigmal plate nearly circular; no ocelli; hind coxæ of male not enlarged 2
   Venter showing more or less distinctly a curved groove behind the anus, but none in front of it; the male with distinct marginal festoons, more or less distinct in the female 4
2. Legs longer than body; tarsi six to ten times as long as broad; coxæ I hardly spinose; on bats ..... *Haemalastor.*
   Legs shorter; tarsi much shorter; coxæ I usually with spine or process behind 3
3. Capitulum slightly angulate on the sides; palpi with the third joint shorter than broad, and broadly rounded ..... *Ceratixodes.*
   Capitulum not angulate on the sides; palpi with the third joint longer than broad and slightly tapering to tip ..... *Ixodes.*
4. Sides of capitulum angulate; ocelli usually present; male usually with anal plates; palpi very short 5
   Sides of capitulum not angulate 7
5. Ocelli present; male with anal plates 6
   Ocelli indistinct, only a faint spot; male without anal plates; palpi without transverse ridges ..... *Rhipicentor.*
6. Palpi with acute transverse ridges ..... *Margaropus.*
   Palpi without transverse ridges ..... *Rhipicephalus.*
7. Outer angle of the second joint of the short palpi acutely produced; no ocelli; male without anal plates ..... *Haemaphysalis.*
   Outer angle of the second joint of the palpi not produced 8
8. Palpi longer, second joint about twice as long as broad; coxæ IV of male not enlarged; basal part of tarsi I, II, and III shorter than apical part 9
   Palpi shorter, second joint barely longer than broad; coxæ IV of male enlarged; basal part of tarsi I, II, and III subequal to apical part; ocelli distinct ..... *Dermacentor.*
9. No ocelli; male with anal plates ..... *Aponomma.*
   With ocelli 10
10. Ocelli marginal; male without anal plates ..... *Amblyomma.*
    Ocelli a little above the margin; male with anal plates ..... *Hyalomma.*

Our own species of *Margaropus* (*M. annulatus* Say) (*bovis* Riley) (figs. 109, 110), is the vector of Texas fever, a disease of cattle that causes enormous losses in the South, particularly in cattle imported there from the north. The southern cattle tick is found only in the Southern States and the Government maintains a quarantine line where cattle brought north may be cleansed of their ticks. The female tick is of a dark, dull-brown color, with a reddish scutum and legs; the male is reddish brown, the legs paler

at articulations. The cause of Texas fever is a minute protozoan parasite, *Babesia bigemina*. This is taken up with the blood of *Margaropus*, which then inoculates each animal that it attacks. And even the young that have not infested any animal may produce the disease. The young ticks (fig. 111), called "seed ticks," are born on the ground; they climb upon grasses or bushes and await the coming of cattle. Each attaches itself at the first opportunity and begins to draw blood. In about a week it molts, remaining on the host during this period. The male increases but little in size, but the female becomes enormously swollen and in about a month she is ready to drop off and deposit eggs (fig. 113). Young or "seed ticks" of the cattle tick may live several months without food, and even remain alive when submerged in water for 3 months. The adults can live for long periods without food, but probably not as long as the argasids. Once in the blood of cattle the parasite destroys the red blood corpuscles and causes a thinness of blood, the hæmaglobin of which appears in the urine. After death the spleen and liver are found to be greatly enlarged. The most promising preventive seems to be the removal of cattle from pasture for one year. This pasture disinfection may be hastened by cultivation for one year, or grazing it to sheep. It has been noticed that southern cattle may become immune, and with this hint a method of vaccination was devised for treating northern cattle when taken south.

FIG. 125.—Tarsus IV of *Amblyomma*. (Original.)

FIG. 126.—Shield of *Haemaphysalis chordeilis*, female. (Original.)

A variety of the cattle tick (*M. annulatus* var. *australis* Fuller) has a posterior median projection to the body; it occurs in tropical regions, and also transmits Texas fever.

The typical species (*Margaropus winthemi* Karsch) and an African species have the hind pair of legs enormously enlarged in the males. Forms closely related to *M. annulatus* Say (subspecies or perhaps distinct species) occur in South America, South Africa, and Australia, and are concerned in the dissemination of the Texas fever, often called "red water." The genus was formerly known as *Boophilus*, but *B. annulatus* is congeneric with the type of the earlier *Margaropus*. There are several other species of ticks found on cattle, but none is known to carry the parasite of Texas fever.

Of *Dermacentor* (fig. 116) there are 9 species in this country, most of them with the scutum more or less variegated with white and brown. The common one is the "dog tick," *Dermacentor variabilis* Say (figs. 114, 115), and is our most widely distributed species. It is found on cattle, dogs, horses, rabbits, and sometimes on man. On the latter it causes no serious consequences, but is a source of much irritation. They are so tightly attached that it is often impossible to remove them without either leaving the head in the flesh or else tearing out a piece of the skin.

D. occidentalis Neumann is common in California and often taken on deer. It is less marked with brown than our other forms, and the white has a more waxy appearance than in our eastern *D. variabilis*.

D. parumapertus Neumann, from California and Arizona, and *D. nigrolineatus* Packard, from the Northern States, are species without marks on the shields; the former attacks mostly small animals, as jack rabbits; the latter is usually on deer or allied mammals.

The *Dermacentor venustus* Banks, which occurs in the Northwest, is the carrier of the Rocky Mountain spotted fever, a serious disease of man. The disease[1] apparently occurs naturally in certain spermophiles inhabiting that region, and has been especially

[1] Produced by *Babesia hominis*.

virulent in part of Montana. The late Dr. Ricketts proved that this tick was the vector of the disease. The tick is colored much as our common dog tick (*D. variabilis*), but the stigmal plate is very coarsely granulated.

D. albipictus Packard (fig. 117) is common in the Northern States on moose, deer, cattle, and horses. It is more elongate than our other species of the genus, and the

FIG. 127.—Head of *Ixodes*. (Author's illustration.)

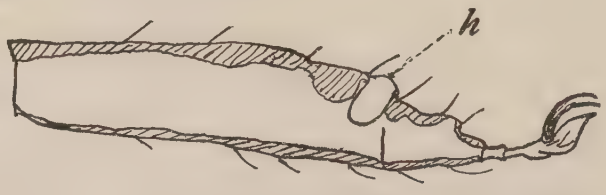


FIG. 128.—Leg I of *Ixodes:* Section through tarsus; *h*, Haller's organ. (Author's illustration.)

stigmal plate has no projection at the end; this species and *D. nitens* do not drop from the host for molting.

D. nitens Neumann occurs in Texas and the West Indies, where it especially attacks horses. The shield has no markings and the stigmal plate has only a few (4 to 10) large rounded granules, and the palpi are shorter than the hypostome.

Another species, *D. hunteri* Bishopp, related to *D. venustus*, occurs in Arizona. The genus is not so well represented elsewhere in the world as it is in North America.

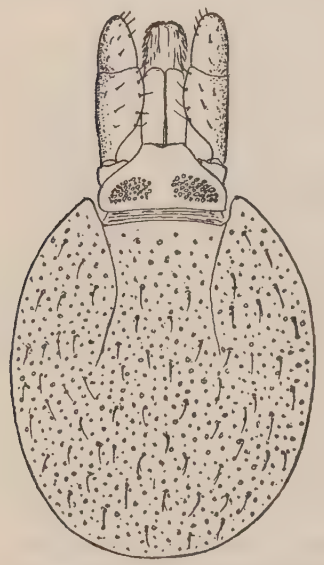


FIG. 129.—Shield of *Ixodes scapularis*, female. (Original.)

Of *Rhipicephalus* (figs. 119, 120) there are a great number of species, most of which occur in Africa; several of the South African forms have been connected with disease. They occur in great numbers on the host, one of them, *R. pulchellus* Gerst. (fig. 121), is very strikingly marked with red-brown and white; it is especially common on the zebra and Cape buffalo. *R. sanguineus* Latr. (fig. 118) is a reddish species, often infesting dogs, and occurs in many warm countries, including Texas and the West Indies. African coast fever (produced by *Theileria parva*) is said to be spread by five different species of *Rhipicephalus*, but *R. appendiculatus* Neumann is the principal vector of the disease. A minute hymenopterous parasite has been bred by Hunter and Hooker from *Rhipicephalus* in Texas and was described by Dr. Howard as *Hunterellus hookeri;* it occurs also in South Africa.

The genus *Rhipicentor* has only a few species in Africa; they resemble *Dermacentor*, but have the structural characters of *Rhipicephalus*. Their coxæ are heavily spined, and there are spines on the hind border of the capitulum.

The genus *Aponomma* is closely related to *Amblyomma*. The species are most abundant in the Australian region, India, and Insulinde. *A. gervaisi* Lucas, a common form, infests tortoises; it is brown, with three greenish spots on the scutum. Some species found on snakes were put in *Ophiodes*, but these are now kept in *Amblyomma*. The genus *Eschatocephalus* (*Haemalastor*) occurs on bats in Europe, especially in caves. Several species are known; all have the legs more elongate than in other Ixodidæ.

Of *Amblyomma* (figs. 124, 125) there are over a hundred species; they are especially abundant in the tropics. *A. americanum* Linn. (fig. 122) is often found on cattle in the Southern States and is called the "lone-star tick" on account of the prominent yellow spot at the tip of the scutum of the female. The male is very much smaller and has

several small yellow marks on the brown scutum. Several species are yellowish, with irregular brownish marks. *A. cajennense* Fabr. (fig. 123) is one of them and is abundant in the tropics of America, extending up into Texas. *A. maculatum* Koch is a handsome species with rich brown and yellow markings, not unlike a *Dermacentor*. It has but one spine on the front coxæ, while other species have two spines. One very large species, *A. tuberculatum* Marx, occurs in Florida on the gopher or tortoise. Some hairy species occur on the giant tortoises of the Galapagos Islands. *A. dissimile* Koch is quite common in the American tropics and is sometimes taken on bullfrogs. None of the species occur in the Western United States, an interesting fact of distribution. None of our species of *Amblyomma* have as yet been associated with the dissemination of any disease, but all are likely to attack man and the domestic animals. In South Africa *A. hebraeum* Koch, commonly known as the "Bont tick," transmits heartwater to sheep and calves, but occurs on a great variety of animals, both wild and domestic.

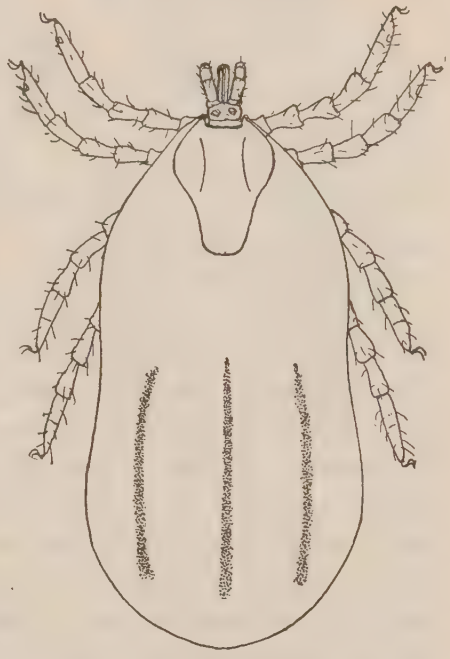


FIG. 130.—*Ixodes marxi:* Female. (Original.)

The genus *Haemaphysalis* (formerly called *Rhipistoma*) is represented in our country by but three species; one, *H. leporis-palustris* Pack., is very common on rabbits, especially in the South and West. The young are often found on the heads of birds that nest on the ground, but the adults of this species are rarely taken on birds. *H. chordeilis* Pack. (fig. 126) is usually found on birds. It has been taken in Vermont on turkeys and is said to be a serious pest, the ticks sometimes being so abundant on young turkeys as to kill them. *H. expositicius* Koch, a European species, has been recorded from Manitoba on cattle. Very possibly it was imported, but it appears to be well established. This species in Europe is often troublesome on sheep. The genus is much better represented in Africa, India, and Insulinde, but in all cases the species are rather smaller than other ticks.

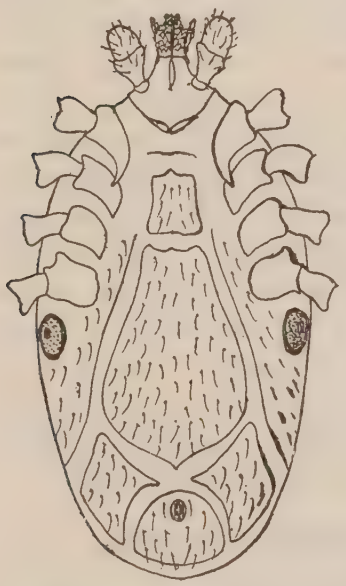


FIG. 131.—*Ixodes:* Venter of male. (Original.)

Of the genus *Ixodes* (figs. 127, 128, 131) we have a number of species, several of which are known from but few specimens. *Ixodes cookei* Packard is the common form in the East, where it occurs on a great variety of small animals. *I. marxi* Banks (fig. 130) occurs on squirrels. In the West, *I. angustus* Neumann is common on the Pacific coast, while *I. kingi* Bishopp occurs on many small mammals in the Rocky Mountain region. In the South, *I. scapularis* Say (fig. 129), a reddish species with almost black legs, is very common, especially in Florida. Most of the species are partial to small mammals and the males are much less common than the females. In Scotland *I. ricinus* Linn. often attacks sheep and appears to distribute the germs of a disease similar to Texas fever that is known by the name of "louping-ill" or "trembling." The parasite is at present unknown. The loss to Scottish herders is sometimes very heavy. It is said that sheep in moist meadows are not as subject to ticks as those in drier pastures. Numerous species of *Ixodes* are found throughout the world and are perhaps more abundant in mountainous parts of temperate countries than elsewhere.

The few species of *Ceratixodes* (fig. 132) occur on large sea birds which live in cold regions. The same species has been taken in the Arctic and Antarctic regions.

A tick has been described under the genus *Ixodes* as taken from a seal near Alaska; but it has not been found again and its position is rather uncertain.

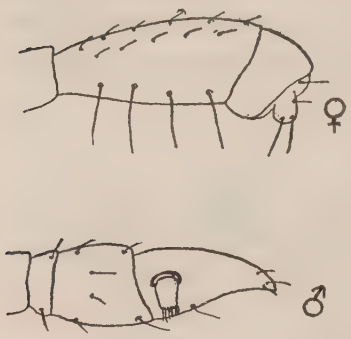


FIG. 132.—*Ceratixodes:* Palpi of male and female. (Original.)

Superfamily PARASITOIDEA.

This superfamily includes three well-marked families, two of which are known from but few species, and have not yet been found in the United States. One of them, the Spelæorhynchidæ, connects the group to the Ixodoidea and shows that the ticks should not be placed in a group of subordinal rank. The families are distinguished on page 18.

FAMILY SPELÆORHYHCHIDÆ.

Under the name of *Spelaeorhynchus praecursor* (fig. 133) Dr. Neumann has described a remarkable mite which he places as a subfamily of the Ixodidæ. This mite, which is less than 2 mm. long, was taken from a Brazilian bat. Another species occurs on bats in Panama. It differs from all ticks in the presence of a sternal plate, and therefore I agree with Oudemans in placing it as a separate family, intermediate in some respects between the Parasitidæ and the Ixodidæ, but more related to the Parasitidæ. The dorsum, as seen in figure 133, shows a curious anterior piece or epistoma, separated by a suture from the rest of the body. This is wholly unlike anything in the Ixodidæ, but more like the epistoma of certain Parasitidæ. The palpi are simple, like those of Parasitidæ, the mouth parts are apparently retractile within a great buccal cavity or camerostome, as in certain parasitids. But the shape of these mouth parts is more like those of the Ixodidæ. There is a distinct median hypostome, unprovided with teeth, and the mandibles are short, the outer tip ending in two stout, curved processes, similar to some ticks. The genital aperture is near the anus, toward the tip of the body, unlike either parasitids or ticks. There are no ventral furrows. The tarsi are furnished with a small caroncle as in the parasitids. Except its occurrence on the bat, nothing is known of its life history.

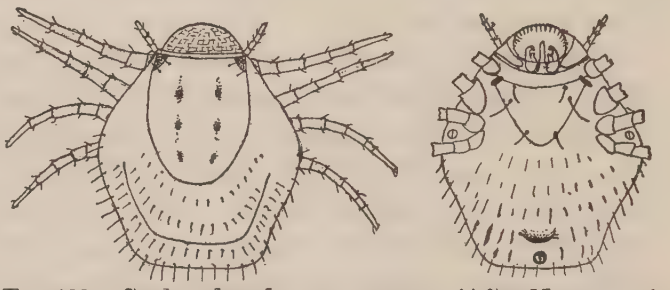


FIG. 133.—*Spelaeorhynchus praecursor.* (After Neumann.)

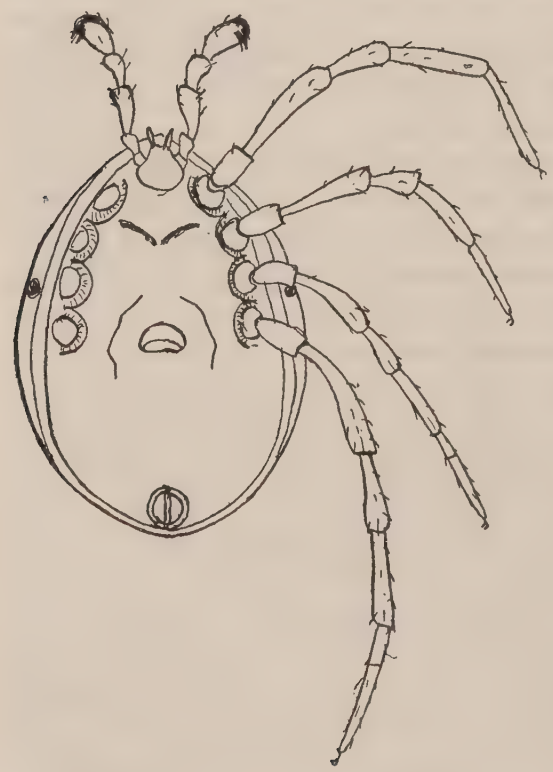


FIG. 134.—*Holothyrus.* (Original.)

FAMILY HOLOTHYRIDÆ.

The species of *Holothyrus* (fig. 134) are moderately large mites occurring under stones or among fallen leaves in New Guinea, Ceylon, Seychelles, and Mauritius. The body is wholly protected by a dorsal and a ventral shield; the spiracles are situate above the third pair of coxæ, just under the edge of the dorsal shield. The legs are slender, sparsely hairy, and each ends in a pair of small claws; the palpi have the last

joint enlarged. The mandibles are chelate, slender, and exsertile. Thorell made a new family for the genus, but other writers consider it related closely to Parasitidæ. The food habits and transformations are unknown.

Family PARASITIDÆ.

The parasitid (figs. 135, 136) mites are among those best known to collectors of insects, since many species are very common, and others spend part of their life attached to beetles and other insects. Typically these mites have a hard coriaceous integument, but there are many exceptions to this rule. They are quite flat, broad, and with rather short legs. They have no eyes, but the sense of touch is very highly developed through many hairs on the legs and body. Some species are slow in movements and are apt to feign death when disturbed, but others can run with considerable rapidity. The mouth parts, in many species, may be completely withdrawn into the body of the mite. The mandibles are normally chelate and the fingers toothed. Sometimes they are greatly elongate and styliform, and thus fitted for piercing; in a few cases the movable finger is lacking. In many species there is a projection or appendage arising near the base of the fingers known sometimes as the "spur," sometimes as the "flagellum." Beneath the mandibles is a large piece, the hypostome. It is bifid and each side ends in an elongate corneous point. Between the two corneous points is a long fleshy part, the lingula. Above the mouth there is in many forms a thin plate, often toothed, known as the epistome. The palpi are prominent and usually five-jointed. In the Uropodinæ the palpi are scarcely visible, as the body projects so much in front. The legs are of moderate length, usually slender, and arise close together, in a row each side. In the Uropodinæ the anterior pair is separated from the others and their coxæ are nearly contiguous. The body is commonly provided with coriaceous plates or shields, the position and shape of which are characteristic of each species. These plates sometimes nearly cover the entire body. Their position and names may be observed from the accompanying illustrations (figs. 135, 136). The scutum, surrounding the coxal cavities, is known as the parapodia; in some cases it forms a little projection behind the hind coxa, which is then called a "squama parapodia." There are some small shields or pieces which are often of importance; a pair just behind the fourth coxæ are called the "metapodia;" a pair just behind coxæ I are known as the "jugularia," and a pair behind sternal plate the "metasternalia." Frequently there are differences between the sexes in the arrangement of the plates, and in the males of many species the ventral plates are mostly coalesced. The female genital opening is commonly under the anterior margin of a plate (the genital) which ends

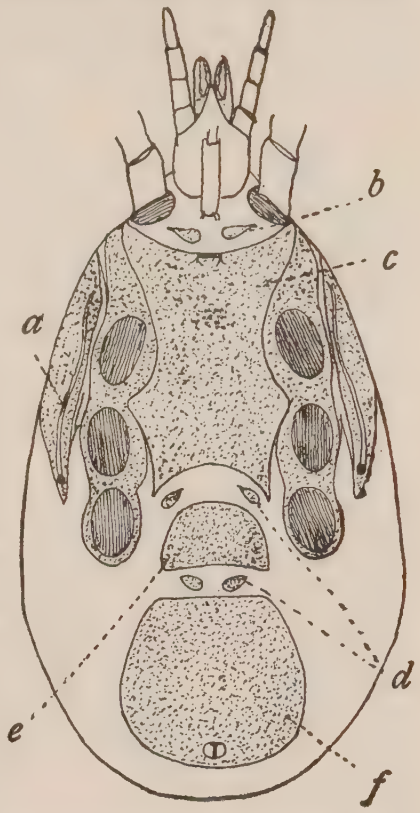


Fig. 135.—Venter of *Parasitus: a*, Peritreme; *b*, jugularia; *c*, sternal plate; *d*, metapodia; *e*, genital plate; *f*, anal plate. (Author's illustration.)

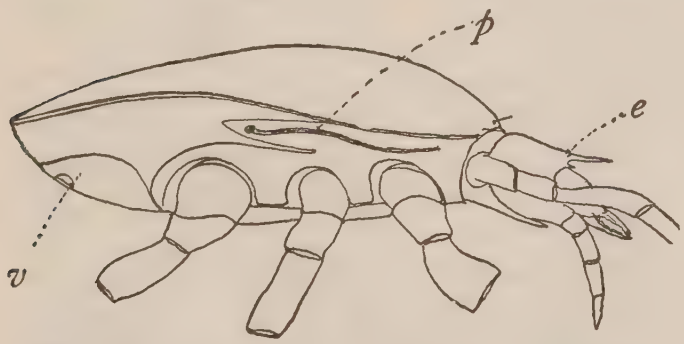


Fig. 136.—Side view of a *Parasitus: e*, Epistome; *p*, peritreme; *v*, anal plate. (Author's illustration.)

near the coxæ of the third legs. The male genital aperture is usually at the anterior margin of the sternal plate, only a short distance back of the mouth. In some groups, notably the Uropodinæ, the genital aperture of the male, or of both sexes, is situate in the middle of the sternal plate. The anal opening is small and placed near the tip of the venter; it is often surrounded by a plate. There is a spiracle or breathing pore on each side of the body, above and slightly in front of the fourth coxa. It is surrounded by a chitinous ring, the peritreme, which usually extends forward for a long distance, often in a slightly sinuous line. The legs are of six joints—coxa, trochanter, femur, patella, and tibia, of subequal length, and a long tapering tarsus. In some species there are indications of a division of the tarsus. The tarsi terminate in two claws, and sometimes a sucker or ambulacrum. In several forms the anterior legs are destitute of claws, and seem to act more as antennæ. In many species the males have the second pair of legs enlarged and provided with teeth and projections, and sometimes the hind legs are also armed.

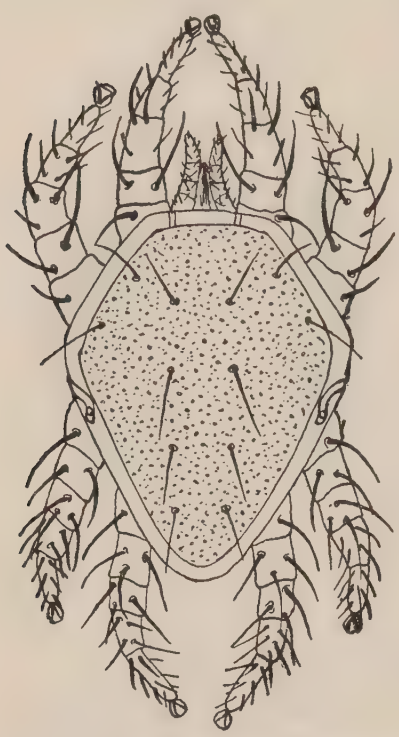


FIG. 137.—*Spinturnix americanus.* (Author's illustration.)

Trägårdh has investigated certain points in the morphology of the Parasitidæ. The sternal area normally has five pairs of bristles, three on the sternal shield, one on the metasternal plates, and one on the epigynal shield. If the sternal plate has four pairs it is evidence that the metasternal plates have coalesced with it. There are sometimes other small sternal plates near the base of the legs that do not bear bristles; these are called endopodal shields. Trägårdh also considers that the numerous shields on the dorsum of *Sejus* indicate segmentation. He also refers to the fact that in those genera in which the male genital aperture is situated in the sternum there is no modification of the male mandibles for carrying the sperm sac.

The internal anatomy of the Parasitidæ has been studied perhaps more than that of any other family. It differs in various ways from what may be called the typical acarid anatomy. Kramer has shown that in some forms there is a tendinous framework in the middle of the body, a sort of internal skeleton, to which are attached many of the larger muscles. The male sexual organs are usually on the common plan. There is, however, a large accessory gland lying between and beneath the vasa deferentia. There is no intromittent organ, and sometimes there are two testes. The female generative organs usually differ much from that in other families. Often there is a semiglobular or botryoidal ovary, opening into one (sometimes two) oviducts, that lead to the vagina; above the vagina is a domed chamber, the spermatheca. At times there are two small glands that open into the vagina. In many forms there is no spermatheca, in which case Michael has discovered the existence of other organs of a most curious nature. Attached to the top of the ovary are two rather clavate arms, known as the lyrate organs; and above is a large sac, the "sacculus femineus," connected at one end to the ovary and at the other by two annulate tubes to the acetabula of the coxæ of the third pair of legs. After the eggs are deposited the sacculus becomes very small. Sometimes it is wanting, but the annulate tubes are present and connect direct to the ovary. The significance

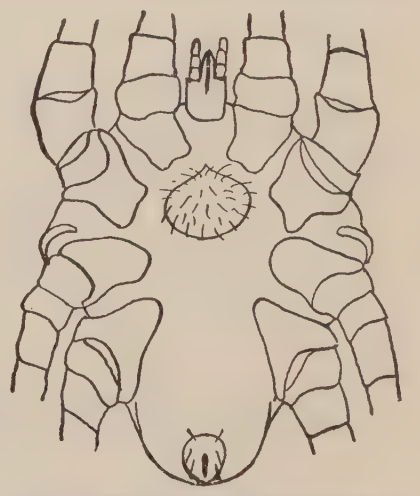


FIG. 138.—Venter of *Spinturnix.* (Author's illustration.)

of these organs is not fully known, but the sacculus contains spermatocysts which are supposed to reach it through the annulate tubes.

Some, if not all, of the Parasitidæ have a most remarkable method of coition, which Michael has discovered and described in detail. The male, which is commonly a little smaller than the female, clasps the latter by the legs of one side and crawls under her. His abdomen extends back beyond that of the female, and he grasps her with his legs. Then a clear sac emerges from the genital aperture of the male, gradually enlarging until it is of full size and shape, which is constant for each species. Usually this sac or bubble is flask-shaped, with a long neck. It incloses the spermatozoa floating in a clear viscid liquid (sometimes within spermatocysts). The male clasps this bubble with his mandibles, which are often modified apparently for such purpose. The male then applies the small end of the bubble to the vulva of the female, often inserting his mandibles for some distance. Here the small end of the bubble bursts and the liquid and spermatozoa are discharged into the spermatheca of the female. The bubble is rather firm, and when empty does not collapse, but shrinks somewhat. After the male leaves the female he proceeds to clean his mandibles. In those species in which the female has no spermatheca, but has annulate tubes connecting to the acetabula of the third pair of legs, it is probable that the bubble is applied to these apertures and not to the vulva, the spermatozoa thus passing into the sacculus fæmineus, from which they may pass into the ovary as occasion demands. In the male of one species there is a hole in the jaw, through which the bubble is pushed, part hanging on either side.

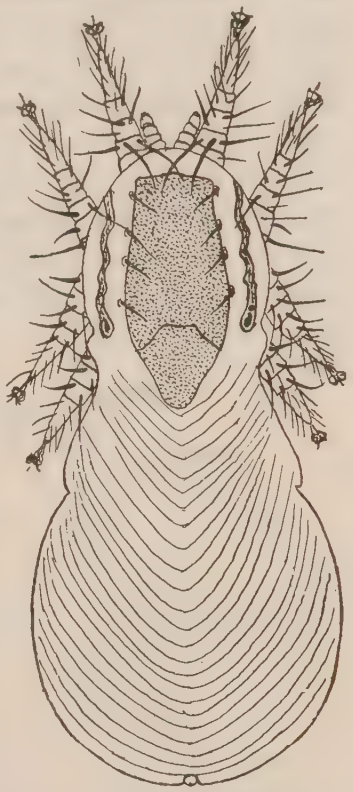


FIG. 139.—*Periglischrus Jheringi:* Female. (Original.)

Trouessart has claimed that in *Raillietia* there is a true parthenogenesis; agamic generations are found in spring and summer, the male appearing only in the autumn or winter. But he may be mistaken, as some other cases of alleged parthenogenesis have been disproved by subsequent investigations.

FIG. 140. — *Sternostomum rhinolethrum.* (Original.)

Parasitids deposit eggs which hatch into pale, soft-skinned, six-legged larvæ, often very different from the adult. There is a remarkable exception in *Pteroptus* and allied genera of the Dermanyssinæ, the young of which hatch with eight legs. Normally the larva molts into an eight-legged nymph. In this stage they have shields, the dorsal often transversely divided. The nymphal stage is often the longest and most active period of their life—the stage of growth and development. After one or two molts in this stage some forms approximate closely in appearance to the adult condition.

Berlese considered that in this family, or at least in certain species, there are several more developmental stages than in other mites. The series included larva, protonympha, nympha, deutonympha, tritonympha, nympha generans, nympha coleoptratæ, and adult. Michael has shown that this is wrong, and that there are only the larva, protonympha, deutonympha, and adult. The larva is known by having but six legs; the protonymph by having a very short peritreme; the deutonymph by having a longer peritreme, and the adults by the development of the genital aper-

tures. Miss Foa has claimed that the forms which, according to Berlese, are stages in the life history of *Holostaspis marginatus* Herm., belong to five distinct species, viz, *H. marginatus* Herm., *H. badius* Koch., *H. merdarius* Koch., *H. confusus* Foa, and *H. submarginatus* Foa, the last two new species. A great many species of Parasitidæ are found attached, often in great numbers, to various beetles; the coprophagous and xylophagous beetles are especially infested with them. Many of these mites when attached to insects are in an immature or nymphal condition, and do not prey upon the beetle, but use it as a means of transportation. It appears that when there is a considerable increase in a species of parasitid mite living in a restricted place, as a rotten log, some specimens have the migratorial instinct which leads them to cling to any moving object; thus, attaching themselves to a beetle that has bred in the log, they are reasonably sure of being transported to a similar locality where they may start a new colony. Most of these mites cling to the host by their feet, but in *Uropoda* and allied genera the mite secretes matter from two glands flanking the

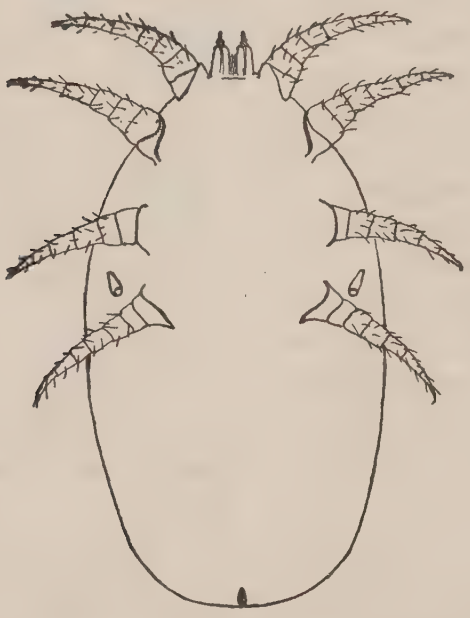


FIG. 141.—*Pneumonyssus simicola*, from below. (Author's illustration.)

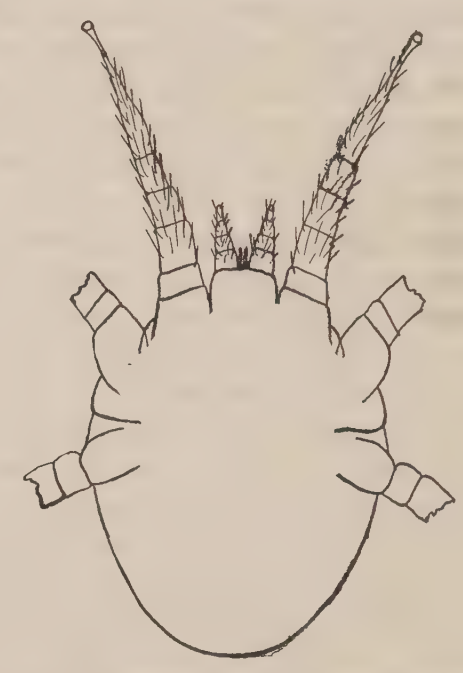


FIG. 142.—Larva of *Pneumonyssus simicola*. (Author's illustration.)

anus which hardens into a pedicel holding the mite fast to the host. Probably the mite is able to loosen at will by the secretion of fresh matter. These nymphal Uropodas thus attached are called nympha pedunculata. It was formerly supposed that all these mites were predaceous upon their hosts, and the *Uropoda vegetans* De Geer was considered a highly beneficial mite for destroying the Colorado potato beetle. There are, however, some parasitids that do feed on the host insect, but are not attached to them. Such forms are very common on tropical beetles. Some parasitids live in decaying substances, either animal or vegetable. It has been shown that certain Uropodinæ live on minute plants, bacteria, and small fungi. Most species prey on small insects, thysanurans, and other mites, as Tyroglyphidæ and Eriophyidæ, and occasionally they will eat one another. The food habits of many are unknown, but from their occurrence they are commonly supposed to be predaceous. There are a few parasitic forms. The entire subfamily Dermanyssinæ is parasitic on birds, bats, rodents, etc. Three genera of the true Parasitidæ are parasitic—*Haemogamasus* on moles, *Laelaps* on various small mammals, and *Raillietia* in the ears of various animals. A great many occur among decaying fallen leaves. A number of species have been taken in ants' nests. Some of these live attached to the ants and obtain food from them. One species is so found on a *Scolopendra*. The relationship of the other forms to the ants is not clear in all cases. It has been shown by Michael that some species of *Hypoaspis* feed upon the dead ants. It is therefore probable that

most, if not all, of these myrmecophilous forms are scavengers, and their presence useful to the health of the colony. The ants sometimes take care of the mites when the nest is disturbed, and carry them to a place of shelter. One species of *Hypoaspis* (*H. equitans* Michael) was frequently observed to jump up on an ant and ride about for a while, the ant taking no notice of its rider. It appears that each species of mite prefers to live with a certain species of ant, but several kinds of mites have been found in the same nest. The mites disappear when the ants desert the nest. Fully 50 of these myrmecophilous mites are known from Europe, a number from Australia, South Africa, and South America, but few from this country.

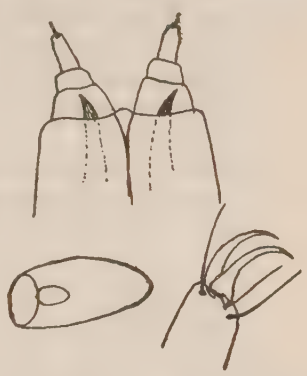


FIG. 143.—*Pneumonysus:* Beak, claws, and stigmal plate. (Author's illustration.)

The classification of this family adopted by Berlese and some other European acarologists is very unsatisfactory, since most of the divisions are based on characters observable in but one sex. A genus should hardly be based on such characters, certainly not a subfamily. His classification is about as follows:

1. Male genital opening in front of the sternal plate..... 2
   Male genital opening in the sternal plate..... 4
2. Second legs of male larger than in the female, and with processes...PARASITINÆ.
   Second legs equal in both sexes..... 3
3. The adult is fully chitinized.....LÆLAPTINÆ.
   The adult is weakly chitinized.....DERMANYSSINÆ.
4. The female genital opening between sternal and genital plates.....ZERCONINÆ.
   The female genital opening in the sternal plate.....UROPODINÆ.

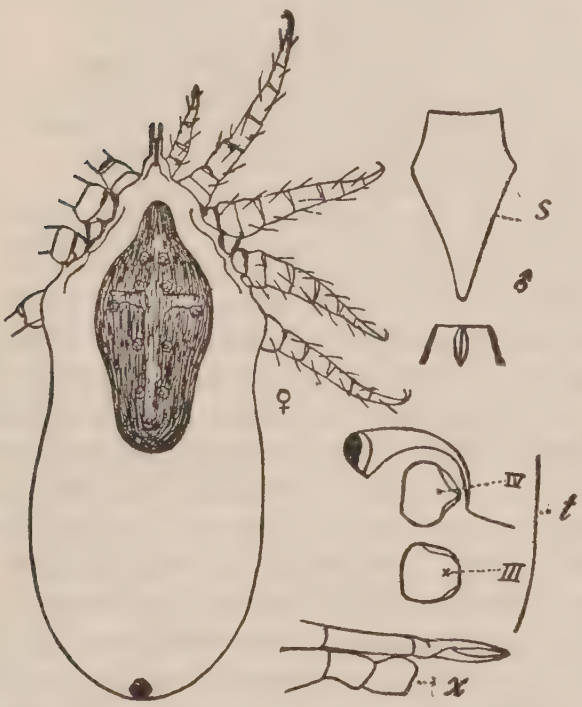


FIG. 144.—*Halarachne americana: s,* Sternum of male; *t,* stigmata and coxæ; *x,* mandible. (Author's illustration.)

The group Dermanyssinæ has long been recognized, and seems upon appearances to be a natural group, but every character so far suggested to separate it from the Parasitinæ or Lælaptinæ is hardly of generic value. I have kept it on the unarmed mandibles, but this is but little better than the other characters, and the group will doubtless have to be merged into the Parasitinæ. Michael uses the position of leg I to separate the Uropodinæ, and this is so much better than the previously given characters that I follow him.

Oudemans has made several arrangements of the genera, one in 11 subfamilies. The characters used are mostly found only in one sex, sometimes the male, sometimes the female, so that it is difficult to use in the identification of specimens. I shall consider that there are 5 subfamilies, which may be tabulated as below:

1. The spiracle and peritreme (nearly or quite) on the dorsum; legs short and very bristly, all with large caroncles.....SPINTURNICINÆ.
   Spiracles and peritremes ventral..... 2
2. No shield or chitinous surface about the anus; parasitic within mammals. HALARACHNINÆ.
   A shield or chitinous surface about anus; not parasitic in mammals..... 3
3. First pair of legs inserted within the same body opening (camerostome) as the oral tube; dorsum of body projects beyond the camerostome; genital apertures in the sternal plate; often occurring on insects.....UROPODINÆ.

First pair of legs at one side of the mouth opening; dorsal surface of body does not project in front of the camerostome; male genital opening usually on the anterior margin of the sternal plate (sometimes in the middle)..... 4

4. Jaws of mandibles without teeth, often stylate or needlelike; parasitic on birds, mammals, or reptiles; tarsus I with claws or caroncles; leg II of male never with processes; anus in female usually at the front end of the anal shield; all the chitinous shields rather weak, and often not evident.....DERMANYSSINÆ.

Jaws of mandibles toothed; rarely stylate or needle-like; usually not found on animals, except insects.....PARASITINÆ.

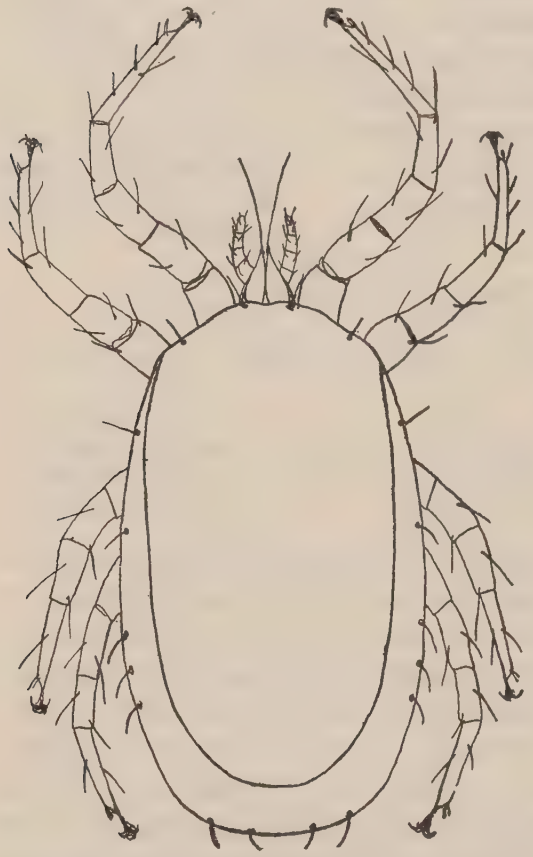


FIG. 145.—*Dermanyssus gallinae.* (Author's illustration.)

The Spinturnicinæ are chiefly parasitic on bats. There are many species of *Spinturnix*[1] (*Pteroptus*), several already described from the United States; the other genera have but few species. The group is remarkable on account of the young hatching with the full complement of legs, the larval stage having been passed in the mother. Although the stigmata are on the dorsum, the peritreme often extends down on the sides.

The principal genera may be separated as follows:

1. Coxæ I contiguous over the rostrum; but one dorsal shield; stigmata without peritreme.....*Sternostomum.*
   Coxæ I separated by rostrum; usually a distinct peritreme..... 2
2. Abdomen constricted behind hind coxæ; peritreme very short; a single dorsal shield.....*Ptilonyssus.*
   Abdomen not constricted or barely so; peritreme quite long..... 3
3. With two dorsal shields.....*Periglischrus.*
   With but one dorsal shield....*Spinturnix.*

Spinturnix (figs. 137, 138), formerly called *Pteroptus*, is parasitic on bats. It is remarkable on account of its curious shape and dorsal position of the stigmata, and also on account of the young hatching with the full complement of legs, the larval stage having been passed in the mother. The abdomen is practically wanting in the male, and in the female it is extremely small. The short, thick, bristly legs are set at about equal distances around the body. Although the stigmata are on the dorsum the peritreme extends down over the sides and upon the venter. Dr. Oudemans has described an accessory nymphal stage in one species of this genus. It occasionally issues from the second nymphal stage and differs particularly in the nature of the vestiture; its use is unknown. Several species have been described from this country. Apparently they do not seriously inconvenience the host, for nearly every bat examined harbors a few specimens.

The genus *Periglischrus* (fig. 139), which occurs on foreign bats, is similar to *Spinturnix*, but has the anterior coxæ separated, two approximated dorsal shields, and the female has a genital shield. The stigma and its peritreme are on the dorsum, the latter quite long and extending parallel to the margin of the shields. The legs are heavy and densely bristly as in *Spinturnix*. The female has a wrinkled, fan-shaped

[1] *Celeripes* Montagu, used by some for this genus, was not described in 1808, but only mentioned; so it is a *nomen nudem.*

expansion at the tip of the body, by which she retains hold of the skin of the bat. Only a few species are known.

Kolenati described several allied genera, but most, if not all, are based on immature stages of species of *Spinturnix*.

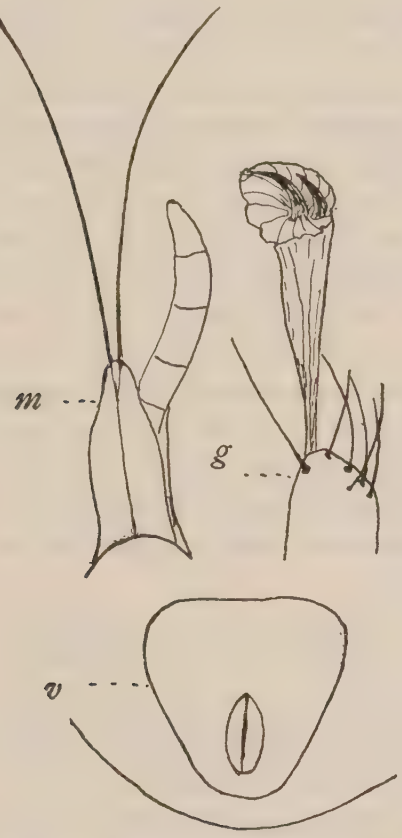


FIG. 146.—*Dermanyssus gallinae: g*, Caroncle; *m*, beak; *v*, anal plate. (Author's illustration.)

FIG. 147.—*Liponyssus americanus.* (Author's illustration.)

The one species of *Ptilonyssus* occurs on sparrows. The legs are but little bristly and not as heavy as in the other genera. Two species of *Sternostomum* are known—one on the swallow, the other, *S. rhinolethrum* Trouess. (fig. 140), on the domestic fowl. It occurs in the nasal fossæ, sucking the blood of its host, and continues to feed long after the death of its host. Zurn and Weber consider that it is the cause of a catarrhal inflammation in the fowls. *Rhinonyssus* is similar in structure and habit and occurs in other birds.

The genus *Ancystropus*, whose species was found on bats, is also related to *Sternostomum*, but leg I is without the caroncle and is very much enlarged, so it may be a distinct genus. Dr. E. Trouessart has united these genera (*Rhinonyssus*, *Ptilonyssus*, and *Sternostomum*) in a special subfamily, the Rhinonyssinæ, based on the dorsal position of the peritreme. None of these forms has, as yet, been taken in the United States.

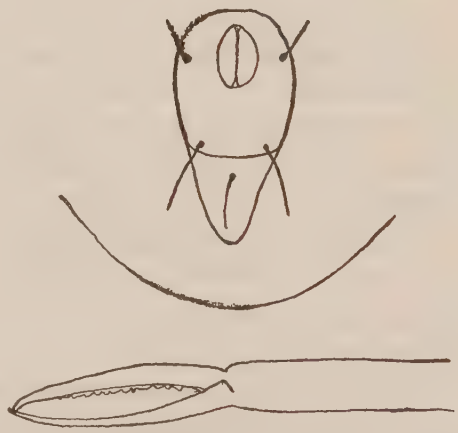


FIG. 148.—*Liponyssus:* Anal plate and mandible. (Author's illustration.)

The Halarachninæ include but two genera—*Halarachne* (fig. 144), which inhabits the bronchial passages of seals, and *Pneumonyssus* (figs. 141, 142, 143), which occurs in the lungs of old-world monkeys. Several species of each genus are now known. *H. attenuata* Banks, from Alaska seals, has a very elongate body. Doubtless there are also other forms in the air passages of other animals. These mites evidently cause or aggravate

an affection of the surfaces attacked by them, since they have usually been discovered when the host has died from some disease of the air passages. It is possible that the apparent relationship of these two genera is a case of convergence due to the peculiar nature of their habitat.

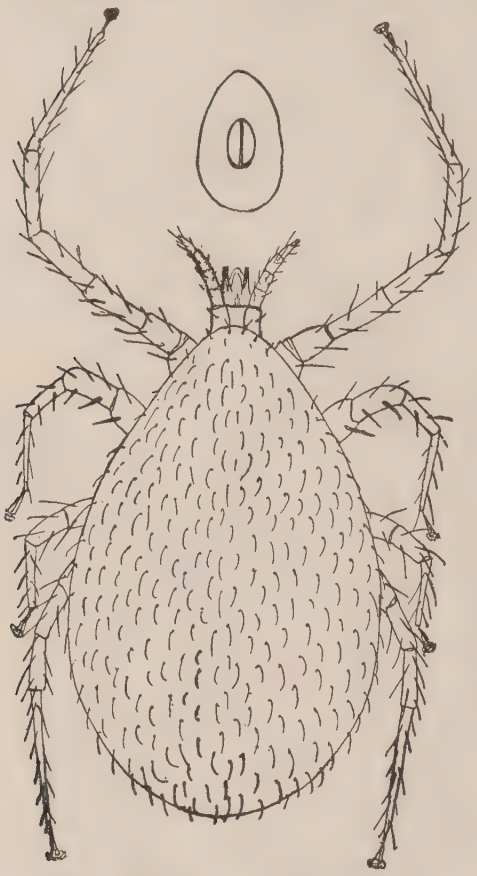


FIG. 149.—*Haemogamasus americanus*, and anal plate. (Author's illustration.)

The Dermanyssinæ are in general very similar to the Parasitinæ, and in the weakly chitinized shields covering only part of the dorsum and the unarmed jaws present the most prominent differences. Several authors cite their parasitic habits as a distinguishing character, but we now know so many species of true Parasitinæ (as *Laelaps*) that also occur on animals that it is doubtful if the group can be maintained distinct from the Parasitinæ.

The genus *Haemogamasus* (fig. 149) appears to belong to this group. It occurs on moles in Germany and Italy; the legs are very slender, the hind tarsi being as long as the width of the body. There are three other genera, which may be tabulated as follows:

1. Vulva longitudinal; occurs on snakes.. *Ophionyssus.*
   Vulva transverse..... 2
2. Mandibles in both sexes chelate..*Liponyssus.*
   Mandibles in the male chelate; in the female long and styliform.....*Dermanyssus.*

The only known species of *Ophionyssus* has been taken on snakes in southern Europe. The species of *Liponyssus* (figs. 147, 148) (formerly known as *Leiognathus*) are parasitic on mice, rats, bats, and related small mammals. Several species are known from the United States and Canada. They also occur in the nests of these mammals. In general appearance they resemble the species of *Dermanyssus*. Gonder (1909) claims that a trypanosome of bats is spread by *Liponyssus arcuatus* Koch. A species of *Liponyssus* (*L. bacoti* Hirst) has been found biting people in stores and factories in Australia; it also occurs on rats in Africa and South America. The species of *Dermanyssus* occur on birds, especially those kept in domestication. *D. gallinae* Redi (figs. 145, 146) is a serious pest to poultry in many parts of the country. They hide in cracks and crevices by day, but at night crowd upon the fowls and suck their blood. They are more injurious in the Southern States than elsewhere. Sometimes they attack man and cause itching and soreness. Chickens endeavor to get rid of the mites by a dust bath, but when the mites are numerous it will be best to spray or wash the henhouse with kerosene, benzine, or gasoline. Whitewashing with carbolated lime will destroy a great many of them. If the ends of the roosts are daubed with coal tar the mites will be unable to reach the fowls. A mixture of kerosene and sulphur plastered upon the roosts and in bottoms of the nests is also very useful. Sulphur flour sprinkled in the nests will also aid in destroying the pests. They breed very rapidly, and if an infested poultry house is not treated in the spring they will make

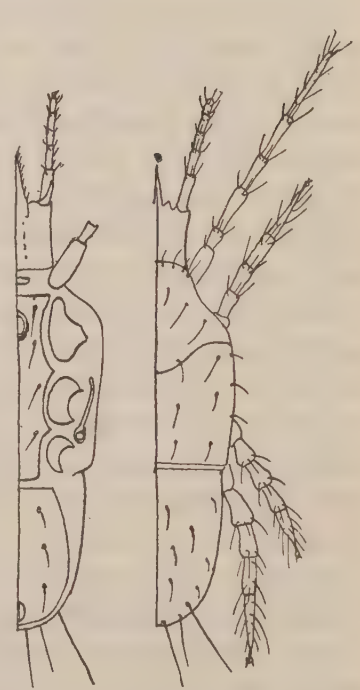


FIG. 150.—*Rhodocarus roseus*, dorsal and ventral aspects. (Original.)

it almost uninhabitable for the fowls by midsummer. The same or an allied species occurs on cage birds.

The genus *Lophoptes* (*L. patavinus* Trouess.) is, in appearance, extremely similar to *Liponyssus*, but it is described as having teeth on the jaws, and so connects this subfamily with the true Parasitinæ. The one species occurs on poultry in parts of southern Europe.

Of the true Parasitinæ there are a host of genera, or rather generic names, many of which can be defined only by slight characters of one sex, and many were proposed as subgenera. Their classification is still in a very unsatisfactory condition, depending too much on characters confined to one sex. The following table gives only the more prominent of these genera, but sufficient for the study of our fauna:

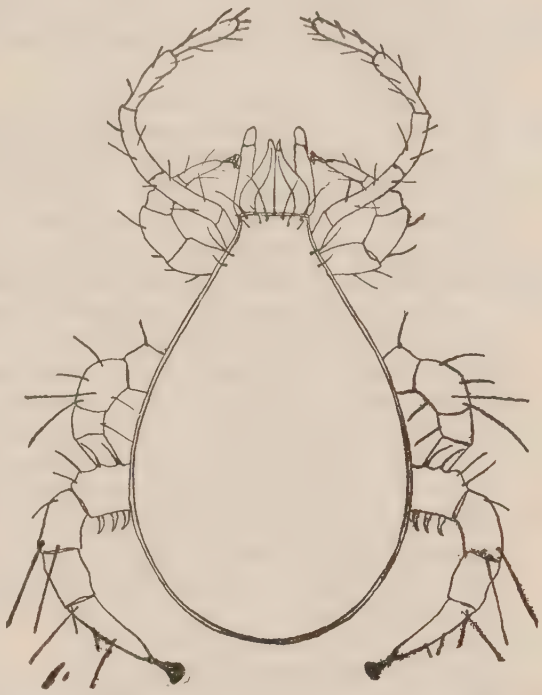


FIG. 151.—*Megisthanus floridanus*. (Author's illustration.)

1. Tarsus I without caroncle or claws; dorsal shield usually entire..... 2
   Tarsus I with either caroncle or claws, or with both..... 8
2. Leg I about twice as long as the body, ending in extremely long bristles; male genital aperture on front of sternal shield..*Podocinum*.
   Leg I not much longer than body. 3
3. Dorsal shield divided; male genital aperture in front part of sternal shield; body elongate; peritreme hardly reaching in front of coxæ II .....*Rhodocarus*.
   Dorsal shield entire..... 4
4. Venter with lateral chitinous plates, separate from the ventral plate, and extending to posterior margin of the body..... 5
   Venter without separate lateral plates reaching to the tip of the body..... 6
5. Anal aperture in the ventral plate.....*Caelenopsis*.
   Anal aperture in the post-ventral plate.....*Euzercon*.
6. Body nearly circular; legs short, first pair with quite long hairs at tip; hind legs without teeth on the femora; male mandibles with a brush of long hair; male aperture in the sternal plate.....Tribe Antennophorini.
   Body elongate, legs longer than width of body..... 7
7. Anal and ventral shields united; male genital aperture on front of sternal shield.....*Macrocheles*.
   Anal shield separate from ventral; male aperture in the sternal shield; often with teeth on hind femora of the male.....*Megisthanus*.
8. With a peritreme scarcely more than twice as long as broad..... 9
   With an elongate peritreme..... 11
9. Tarsus I without caroncle, only claws; leg I very long and slender; male aperture in sternal plate; stigmal plate circular.....*Epicrius*.
   Tarsus I with caroncle and claws; all legs short and stout; male genital aperture in front of sternal plate; stigmal plate about twice as long as broad..... 10
10. Coxæ with spines; leg I with stout bristles.....*Paragreenia*.
    Coxæ without spines; leg I with slender hairs.....*Iphiopsis*.
11. Dorsum with several small and two large shields.....*Sejus*.
    Dorsum with at most two large shields..... 12
12. Male genital aperture in the middle of the sternal plate; female with the ventro-anal plate occupying nearly all the space behind hind coxæ, not united to the genital plate; vulva not large; claws of hind tarsi not long pedicellate..... 13
    Male genital aperture in front of the sternal shield; in the female, when anal and ventral plates are united, it does not occupy all the space behind hind coxæ..... 14

13. Dorsal shield divided; body more elongate, and truncate behind ..... *Zercon*.
    Dorsal shield entire; body rounded ..... *Seiodes*.
14. Leg II of male with processes below; vulva often large; claws of hind legs often long pedicellate (Parasitini) 20
    Leg II of male without processes; vulva never very large, often but a transverse slit; claws of hind legs not long pedicellate; dorsal shield not divided (Laelaptini) 15
15. Hind femora calcarate; genito-ventro-anal shield in one; leg I long and slender ..... *Neoberlesia*.
    Hind femora not calcarate 16
16. No claws, but large caroncles to the tarsi; anal plate separate ..... *Myrmozercon*.
    Claws as well as caroncles to the tarsi 17
17. Coxæ and ventral shield with stout bristles or spines; epistoma short, rounded; parasitic on small animals ..... *Laelaps*.
    Coxæ and ventral shield at most with hairs 18
18. Anal plate of male united to the other plates; female genital and ventral plates often united; epistome usually elongate and toothed ..... *Hypoaspis*.
    Anal plate separate in both sexes 19
19. Epistome with a long, hairy, median spine; anal plate rather small .... *Hyletastes*.
    Epistome scarcely pointed; ventro-anal plate usually large and broad .... *Seiulus*.
20. Female ventral shield united to the genital, not to the anal; vulva scarcely in front of coxæ IV; dorsal shield entire ..... *Pachylaelaps*.
    Female ventral shield not united to the genital 21
21. Female genital shield triangular, anteriorly pointed; hind tarsal claws usually long pedicellate 22
    Female genital shield not anteriorly pointed; hind tarsal claws short pedicellate 23
22. Female dorsal shield divided ..... *Parasitus*.
    Female dorsal shield entire ..... *Hologamasus*.
23. Dorsal shield entire in both sexes ..... *Hydrogamasus*.
    Dorsal shield divided in both sexes 24
24. Female anal shield united to the ventral shield ..... *Gamasellus*.
    Female anal shield separate from the ventral shield ..... *Cyrtolaelaps*.

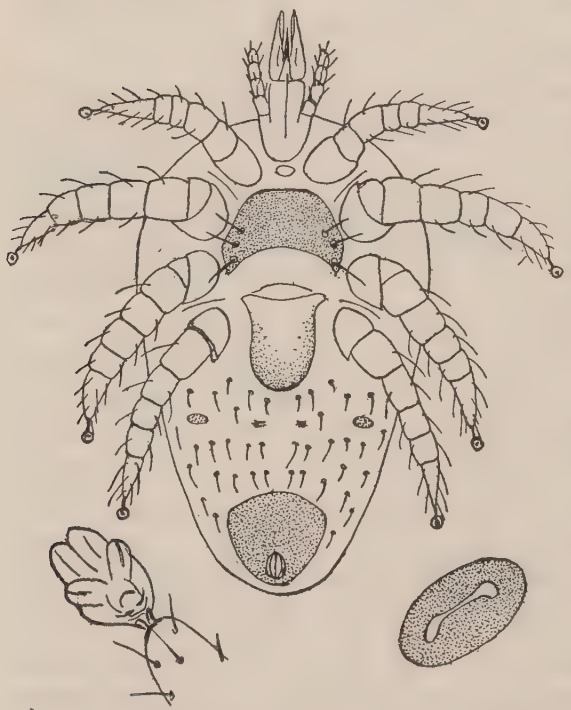


FIG. 152.—*Iphiopsis* sp., caroncle and peritreme. (Original.)

Besides those tabulated above there are a great many genera and subgenera proposed in recent years, mostly by Berlese. Most of these differ from others only in minute characters usually present in but one sex; the more prominent of these genera are referred to below.

In *Epicrius*, which has not yet been recorded from this country, the dorsum has a regular pattern of tubercles.

Several species of *Caelenopsis* (fig. 156) have been described; one was found attached to a histerid beetle, *Hololepta*, another on *Passalus*, and the third on the larva of a beetle. There are many tropical species of the genus.

The remarkable genus *Rhodocarus* (fig. 150) is known from only one species, which occurs in Europe.

The genus *Euzercon* has the ventral plates as in *Caelenopsis*, but the anal plate is small and separate; there are no claws to the front legs and the body is margined by a row of long stout bristles. The species are from South America.

Megisthanus includes a number of large tropical parasitids, recognized by their large size and toothed hind femora. One species, *M. floridanus* Banks (fig. 151), has been taken in Florida. Some species are 4 mm. long and have a caudal projection fringed with hairs. They are most abundant in the Malay Archipelago.

The species of *Iphiopsis* (fig. 152) have short, stout legs, not very bristly; they have been found on myriapods; two species from Java were considered as forming a new subgenus *Jacobsonia* (*Greeniella* Berl. non Bks., non Ckll.). Their relations to the

FIG. 153.—*Macrocheles carclinensis:* Female. (Author's illustration.)

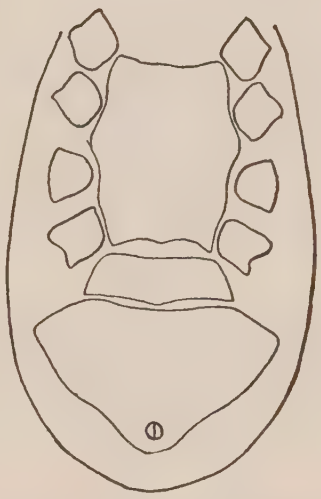


FIG. 154.—*Macrocheles carolinensis:* Venter of female. (Author's illustration.)

myriapods are unknown, but they probably secure food from the host. One species occurs in Florida. *Hyletastes* (figs. 165, 166) includes rather small, short-bodied species, most of which have been found on scarabæid beetles, but a few in moss. Those forms having long bristles around the margin of the body have been called a new genus, *Copriphis*. In the Tropics are many species of this genus, often found attached to scarabæid beetles; Berlese has divided it into several genera.

Macrocheles (figs. 153, 154, 155) includes some of our most common species, but few have been described; one (*M. moestus* Banks) occurs in the nest of an ant, *Lasius americanus*. Others are found attached to insects, some are found on flies, but nearly all normally breed in manure or decaying matter. Most of the species are of large size. *M. badius* Koch, an European species, is found attached to flies bred from manure. *Holotaspella* is a subgenus of *Macrocheles* for species with a sculptured dorsum. *Sejus* (fig. 157) is a remarkable form, found in the northern part of this

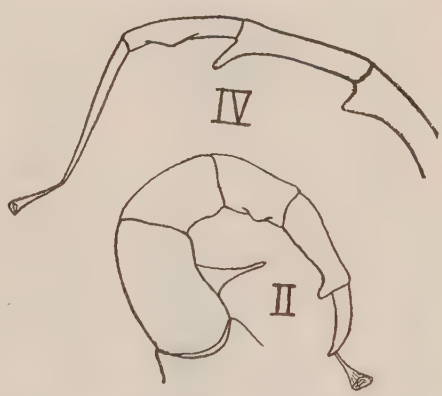


FIG. 155.—*Macrocheles spinatus:* Legs II and IV of male. (Author's illustration.)

country; similar species, with the dorsal shield broken up into numerous small ones, are found in northern Europe.

The genus *Raillietia* Trouessart is based on the *Gamasus auris* Leidy, taken from the ears of cattle. It is closely related to *Parasitus*, the male having the second pair

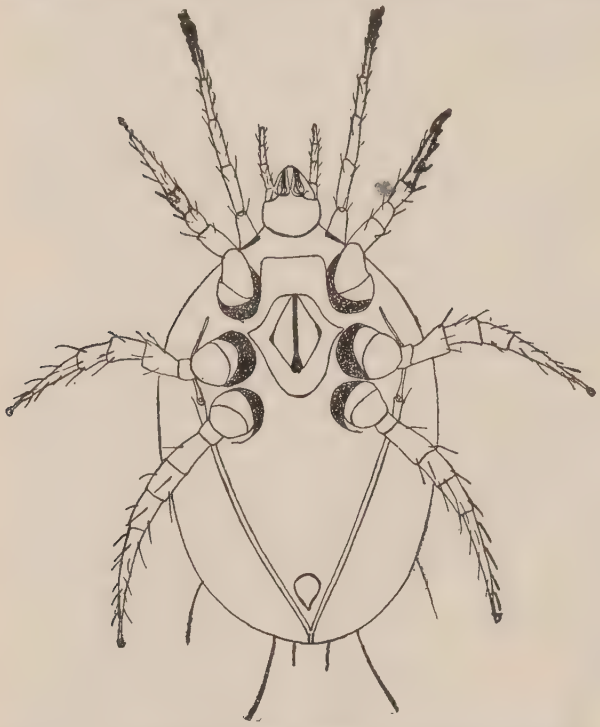


FIG. 156.—*Caelenopsis americana.* (Author's illustration.)

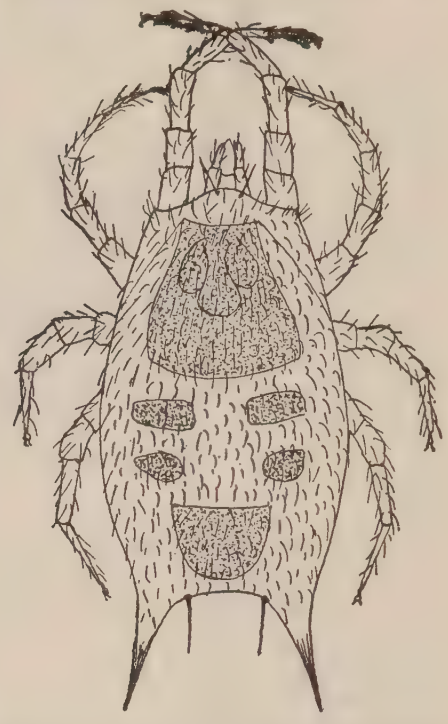


FIG. 157.—*Sejus americanus.* (Author's illustration.)

of legs calcarate. Trouessart thought he had observed parthenogenesis in this species but he was probably in error, as various cases of supposed parthenogenesis have been shown to have been mistakes.

FIG. 158.—*Paragreenia alfkeni.* (Original.)

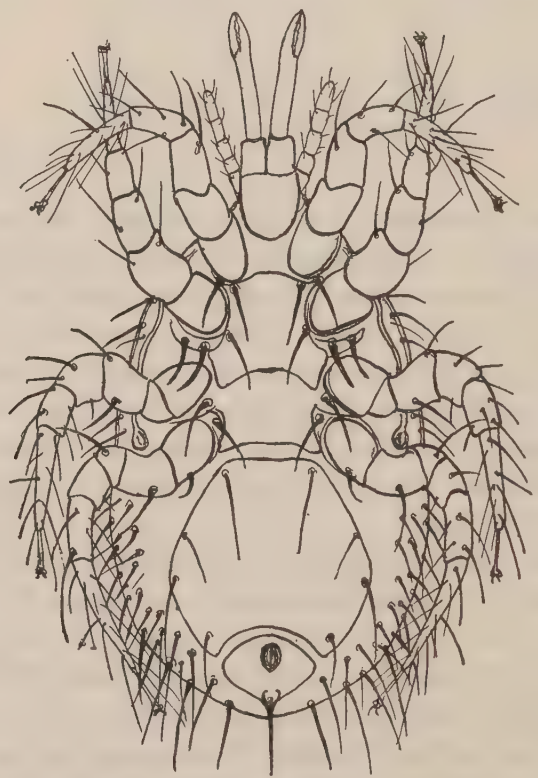


FIG. 159.—*Laelaps echidninus.* (Original.)

Heterozercon is based on a South American species (only the female known) in which there is a suckerlike disk each side of the anus; the dorsal shield is entire, the peritreme long, and leg I with claws. *Discozercon*, from Java, is a similar form.

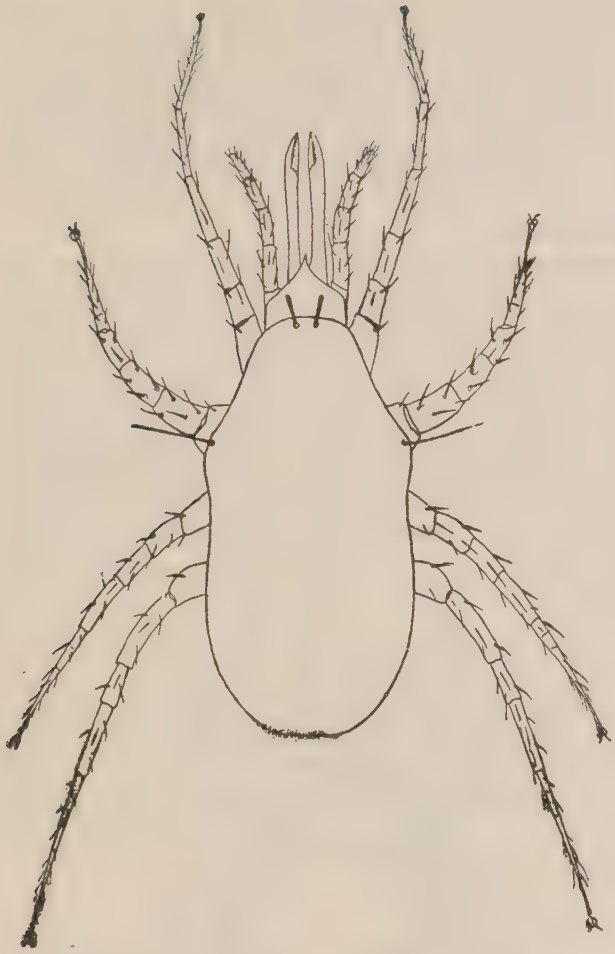


FIG. 160.—*Parasitus* sp. (Author's illustration.)

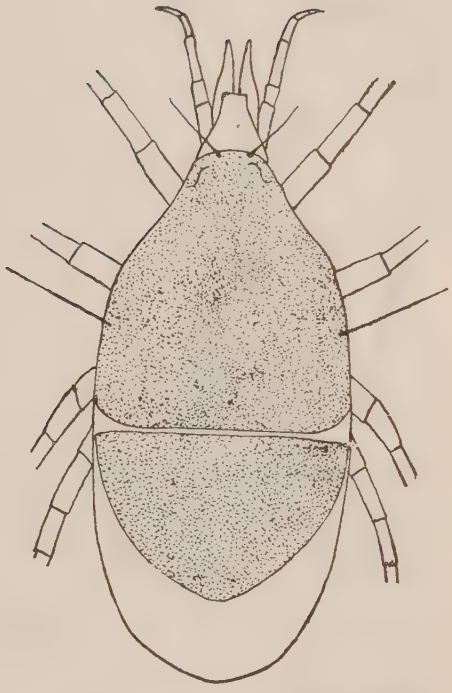


FIG. 161.—*Parasitus* sp.: Nymph. (Author's illustration.)

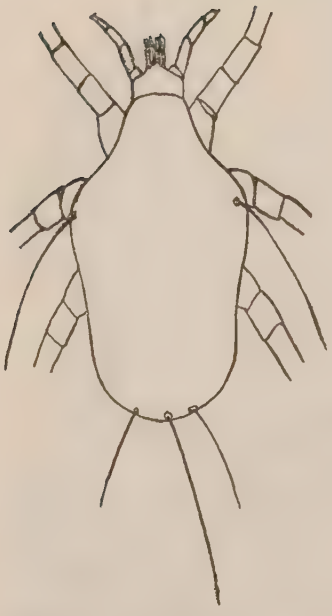


FIG. 162.—*Parasitus* sp.: Larva. (Author's illustration.)

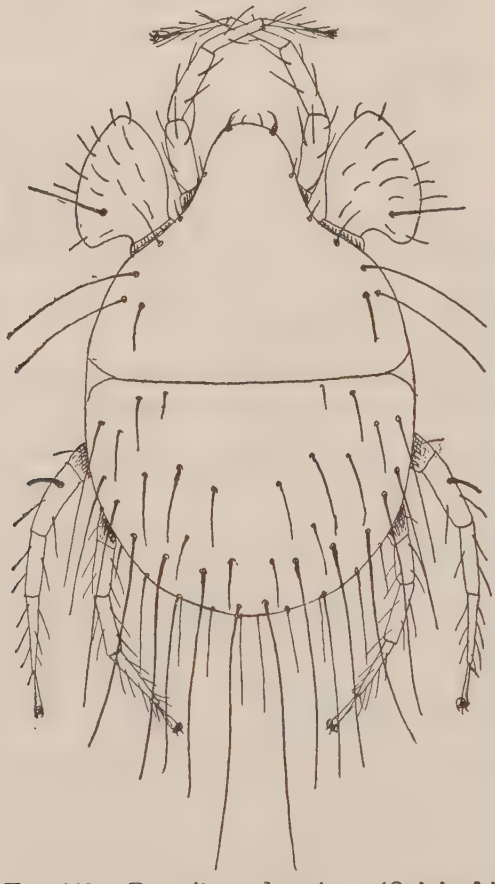


FIG. 163.—*Parasitus calcarator*. (Original.)

Parasitids of various kinds occur on the seacoasts, and often have the caroncles modified or enlarged and adapted to the moist soil. Several new genera have been based on such forms as *Cyrthydrolaelaps*, which is a *Cyrtolaelaps*, except the peculiar foot. Most of these maritime forms have evidently been developed independently from the adjacent parasitid fauna, and exhibit convergence in structure. Very similar forms are known from the coasts of Europe and from certain Antarctic islands.

FIG. 164.—*Parasitus predator:* Leg II of male. (Original.)

The genus *Podocinum* is remarkable on account of the very long front legs, which the mite uses as feelers. The species occur under sticks on moist ground; one of our species is very common. The species of *Paragreenia* (fig. 158) (*Greenia* Ouds. and *Greeniella* Bks., both preoccupied) are remarkable for inhabiting a cavity in the basal abdominal segment of certain female bees of the genus *Koptorthosoma*. With them have been found other mites, especially of the genus *Trichotarsus*. The relation of the mites to the bees is not fully known; the basal segment of these bees is strongly concave and its edges applied closely to the tip of the thorax, thus forming a cavity with an opening above. Within this cavity the *Paragreenia* occur, often nearly filling it. These mites have the front legs provided with short retrorse spines; several species have been described, all from the Old World. In the female of an American species of *Odynerus* a similar cavity is found where the apical margin of the basal segment rests on the front of the nonconstricted part of the segment; a similar but undescribed genus of mites occurs in this cavity.

Anystipalpus is in general similar to *Laelaps* but with the palpus formed on the manner of the Trombidiidæ, the last joint forming a "thumb."

Of *Myrmozercon* (including *Myrmonyssus*) a large number of species have been described, mostly from southern Europe. They are found attached to the bodies of various species of ants, and doubtless feed upon them. They have short, stout legs with very large ambulacra.

FIG. 165.—*Hyletastes* sp. and anal plate. (Author's illustration.)

A number of species of *Laelaps* occur on small mammals and in their nests; thus *L. multispinosus* Banks occurs on the muskrat, *L. pedalis* Banks on the chipmunk, *L. propheticus* Banks on the groundhog, and *L. echidninus* Berlese on rats. They are supposed to suck the blood of their hosts, but may feed to some extent on the dermal scales. *L. echidninus* Berlese (fig. 159) is a very bristly form; it is found on rats in all parts of the world, but probably has little to do with the transmission of any human disease. Two other species have also been recorded from rats. Unlike the ticks, these mammal-inhabiting mites rarely if ever attack man or the domestic animals, so that they are of little economic importance. But as vectors of plague from rat to rat they are factors that must be considered in the eradication of that dread disease. According to recent researches, *Laelaps echidninus* also carries a disease

peculiar to rats, produced by a sporozoan, *Hepatozoon perniciosus*. The sexual cycle occurs within the *Laelaps*, so that it is a necessary factor in this disease.

The genera *Poecilochirus* and *Gamasoides* are very near *Parasitus*, but have a membranous appendage to the movable finger of the mandibles. *Gamasoides* has stout spinelike bristles above on the femora.

The genus *Parasitus* [1] (figs. 160, 161, 162) includes a host of species all over the world; but few of ours have been described, and several are apparently identical with some of the European species. Berlese and others have split the genus into a great number of subgenera, most of which are difficult to recognize in both sexes. The species of *Parasitus* (figs. 163, 164) are mostly found running freely among fallen leaves in the woods, or in heaps of refuse or débris. Rarely are they attached to insects or occur in ant nests. Several inhabit sea beaches, often below the high-water mark. They are always predaceous, and are sometimes beneficial in destroying springtails and injurious mites. Most of the species have the same general habitus, and are difficult of separation. The European forms have been monographed by Berlese.

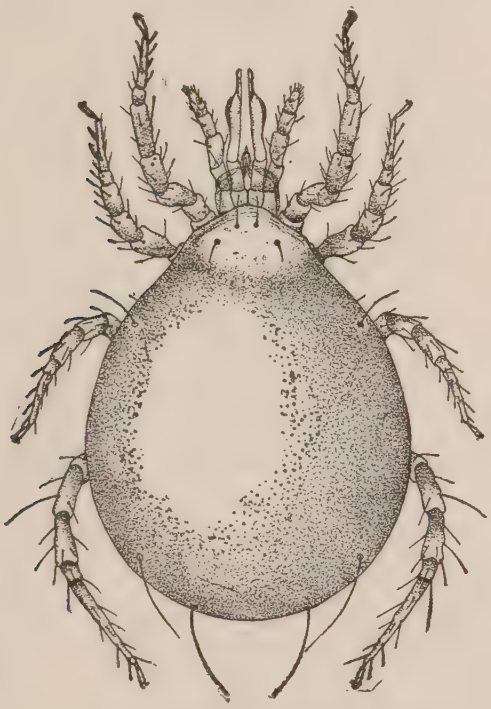


FIG. 166.—*Hyletastes ovalis*. (From Marlatt.)

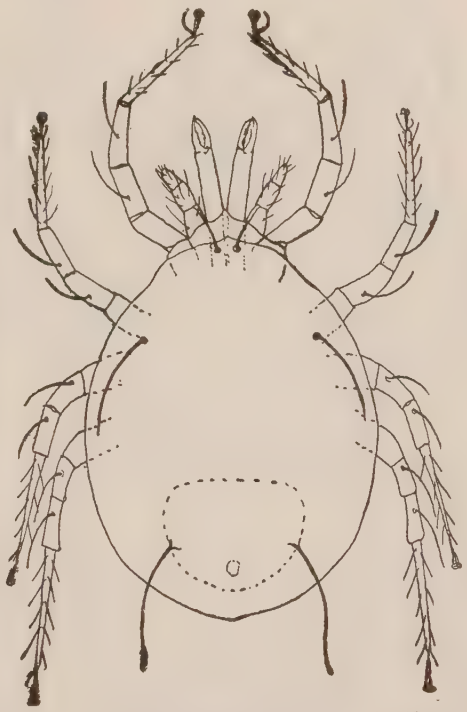


FIG. 167.—*Seiulus quadripilis*. (Author's illustration.)

In *Seiulus* (fig. 167) are placed many small species, which are quite simple in structure, often with some long bristles; they usually occur in moss, but sometimes on the leaves of plants, rarely attached to insects. They are predaceous in habit and feed on thrips and red spiders.

Melichares is closely related to *Hypoaspis*, but the dorsal shield of the female is slender, hardly more than one-half as wide as the body.

To the genus *Hypoaspis* (figs. 168, 169) belong a great number of species, most of which were formerly placed in *Laelaps*. Their habits are extremely varied; a number are found in the nests of ants, some attached to the ants, others feeding on the débris or attacking the eggs of the ants; several species are attached to beetles or other insects; others occur in moss, and a few in decaying vegetable matter, or among dead leaves. Berlese has divided the genus into 6 subgenera, depending on the condition of the ventral plates in the female, or on whether the second pair of legs of the male is provided with spurs. These subgenera are *Laelapsis*, *Eulaelaps*, *Cosmolaelaps*, *Hoplolaelaps*, and *Androlaelaps*. One of our species has been taken in an ant nest, and another (*H. placidus* Banks) from wet sphagnum moss.

[1] This genus is known to all acarologists as *Gamasus*, and it is very unfortunate that this name is antedated by the less-known one of *Parasitus*.

Under the name Antennophori (fig. 170) are placed a number of species and genera usually associated with ants. This group is recognizable on account of the generally circular shape and short legs, the first pair of which lacks the claws and caroncle, but is provided with long hairs at the tip. The dorsum is covered by an entire shield, and the male genital aperture is in the sternal plate. The habits of these mites are intensely interesting. The adult mites occur on ants or myriapods, one species, however, on an earth-boring beetle, *Scarites*. Those on ants (fig. 171) are usually upon the head or venter. The ants are accustomed to touch one another by the antennæ in asking for food; the ant having food thereupon regurgitates a drop, which is taken by the other ant. The mites come in here and secure a bit; by touching with their front legs the ant they are on, or another ant that comes near, the mites imitate this request for food, the ants often responding. Janet has claimed that the mites arrange

FIG. 168.—*Hypoaspis mexicanus*, mandible, and enlarged hair. (Author' sillustration.)

FIG. 169.—*Hypoaspis macropilis* and caroncle of tarsus IV. (Author's illustration.)

themselves systematically on the ants so that they balance and do not disturb the equilibrium of the ant. Thus when there is but one mite present it clings to the median surface of the head; when two are present, one is situated each side of the head; if three, one each side and one in the middle; if four mites, then two each side, usually one pair on venter; if six are present, then placed as with four, and a median one on head and venter. One can hardly believe that any such definite arrangement is regularly maintained. The species occurring on myriapods are supposed to feed on the secretion of the repugnatorial glands. They do not arrange themselves symmetrically on the host, and move about very rapidly if disturbed. They can travel as easily sideways or backwards as forwards, and to this fact, Trägårdh thinks, is due their circular shape. Only the adults occur on insects, the immature stages, at least with the myriapodophilous species, according to Trägårdh, occurring in fallen decaying leaves. The

female deposits one large egg at a time. In the male the lower claw of the chela, or mandibles, is provided with a brush of long hairs, which is considered to assist in transferring the sperm at mating. Most of the species are hairy all over the dorsum, others only around the margin. They occur in Europe, Africa, Australia, and South America, and three are known from the United States.

A number of genera have been made, but most of these are scarcely more than subgenera and based largely on the females. They are distinguished as below:

1. But one genital shield ..... *Parantennulus.*
   With three genital shields 2
2. Shields near vulva partly cover it, the anal united to the ventral ... *Physalozercon.*
   Shields near vulva do not cover it 3
3. The ventro-anal shield elongate, not occupying the available space. *Antennophorus.*
   The ventro-anal shield very broad, occupying all available space 4
4. The shield near vulva united to the ventro-anal shield. *Neomegistus, Echinomegistus.*
   The shield near vulva separate from ventro-anal shield 5
5. Metasternum divided ..... *Paramegistus.*
   Metasternum entire ..... *Antennomegistus.*

A closely related genus, *Ophiomegistus*, occurs under the scales of certain snakes in the Philippines. They are so flat that they can not be noticed under the scales, but leave the snake when the latter is placed in alcohol.

In *Ptocharus*, an Australian form occurring on ants, the abdomen may become greatly distended with food, becoming nearly as high as broad.

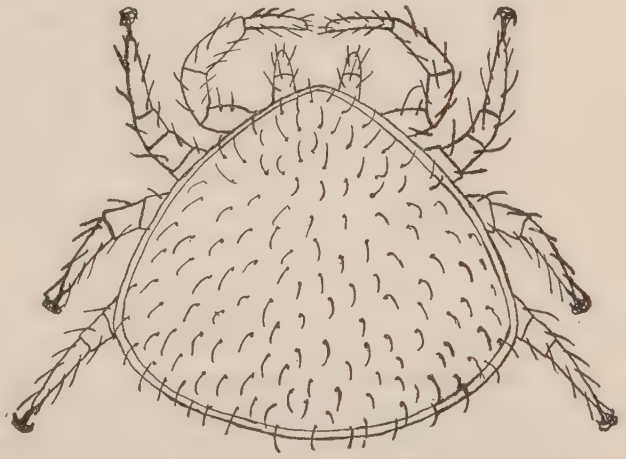


FIG. 170.—*Antennophorus uhlmanni.* (After Haller.)

In general appearance the Uropodinæ (fig. 172) are quite different from most of the Parasitinæ, being shorter and their legs more or less hidden under the body. They are familiar to most entomologists when attached to beetles and other insects. Besides the character given in the table for the separation of these forms from the Parasitinæ, it may be added that the mandibles are very long and slender, ending in delicate chelæ. In fact, the mandibles in some species are twice the length of the body and when retracted the bend near the middle almost reaches the posterior walls of the body. Most of the Uropodinæ that are found on insects are there for the purpose of transportation and not as parasites, but in certain forms found on ants the mite is a true parasite. The species that use the insect as an aid to migration are attached thereto by a pedicel of matter secreted by glands near the anus; those that are true parasites are not so attached. Most of those that are attached by this anal pedicel are not adults, but in a nymphal stage and are called "nympha pedunculata." The mite can detach itself by a fresh secretion. They occur on insects that breed in places suitable for the mites. Therefore the mites are sure to be carried to a spot where they can drop off and find the desired breeding grounds—decayed wood, humus, manure, or fallen leaves. Sometimes the insect is so completely covered by the mites that it can not be seen. They have been found attached to wood lice (*Porcellio*) and to caterpillars. Cummins has shown that *Uropoda* feeds on bacteria and minute fungi that grow on the substances inhabited by the mite. He made many experiments with them. On placing the bacterial matter on a slice of potato near the mites they would, through some sense, at once

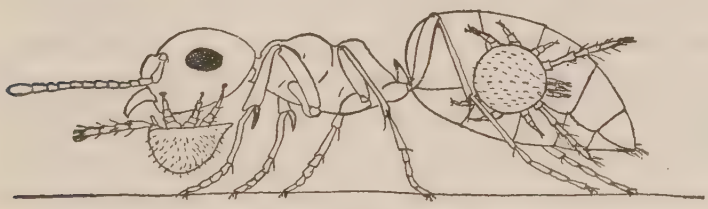


FIG. 171.—Ant carrying three Antennophori. (After Janet.)

discover the food, hasten to it from all sides, and scramble to eat it as fast as possible. By destroying the bacteria and fungi the mites delay decomposition, but can not prevent it. During the past few years many new genera and subgenera have been formed in this subfamily, mainly at the expense of the former *Uropoda*. The characters are of apparently slight value, and sometimes in only one sex. I have therefore included only a few of them in the following synopsis of the genera:

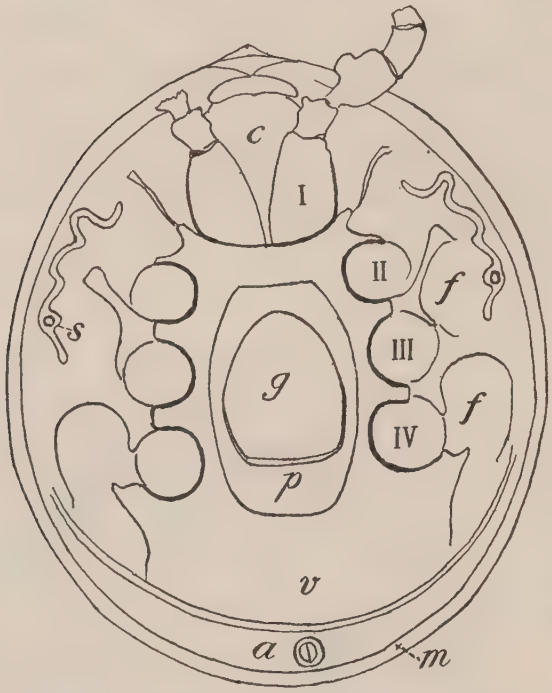


FIG. 172.— *Uroplitella: a*, Anal plate; *c*, camerostome; *g*, genital plate; p, perigenital plate; *m*, marginal plate; *s*, spiracle and peritreme; *v*, ventral plate; *f*, foveae; *I*, coxa I; *II, III, IV*, coxal cavities. (Original.)

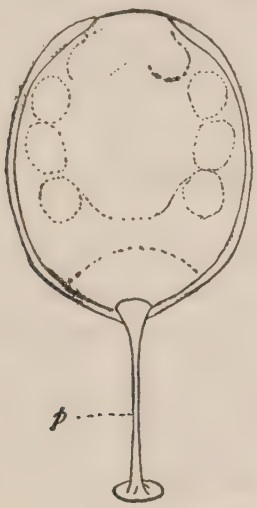
FIG. 173.— *Uropoda:* Caroncle and peritreme. (Author's illustration.)

1. Venter provided with impressed foveæ for the reception of the legs..... 2
   Venter without such foveæ..... 6
2. Leg I without claws, ending in bristles..... 3
   Leg I with claws, and caroncle, at tip..... 4
3. Body about as broad or broader than long; dorsum smooth..... *Cilliba.*
   Body longer than broad; dorsum sculptured or roughened..... *Discopoma.*
4. A perigenital scutum around the genital plate..... *Uroplitella.*
   No perigenital scutum..... 5
5. Dorsum smooth or punctured, not sculptured..... *Uropoda.*
   Dorsum roughened or sculptured..... 9
6. Leg I without claws..... 7
   Leg I with claws..... 8
7. Legs with scalelike hairs; dorsal and ventral plates separate and distinct..... *Polyaspis.*
   Legs without such hairs; no ventral plate..... *Uroseius.*
8. Dorsum covered by one plate fused to the ventral plate; peritreme sinuate; anterior coxæ contiguous..... *Dinychus.*
   Dorsum with several plates not fused to the ventral plate; peritreme but little curved; anterior coxæ separate..... *Trachytes.*
9. The anterior part of body, or hood, distinctly separated from the rest of the body by a suture..... *Cephalouropoda.*
   The anterior portion not separated by a suture..... *Trachyuropoda.*

But few species have been described from this country, although they are extremely common and easily obtainable, and their habits are as interesting as those of any of the acari. Most of the species are found in decaying matter, as manure, rotton logs, fallen leaves, usually where insects are breeding, having been carried to the place by these insects. *Uropoda* (figs. 173, 174, 175) may be divided into two subgenera— *Uroobovella*, in which the anal plate is more or less distinct from the ventral

plate, and *Uropoda*, in which the anal plate is wholly united to the ventral without trace of a suture.

Species of *Uropoda* are frequently found attached to various beetles. One of these is common on the Colorado potato beetle, and it was formerly supposed by many economic entomologists that the mites fed upon the beetle. It has lately been shown that some species feed on bacteria and small fungi. The species are very numerous;



TIG. 174. — *Uropoda* sp.; *p*, Pedicel. (Author's illustration.)

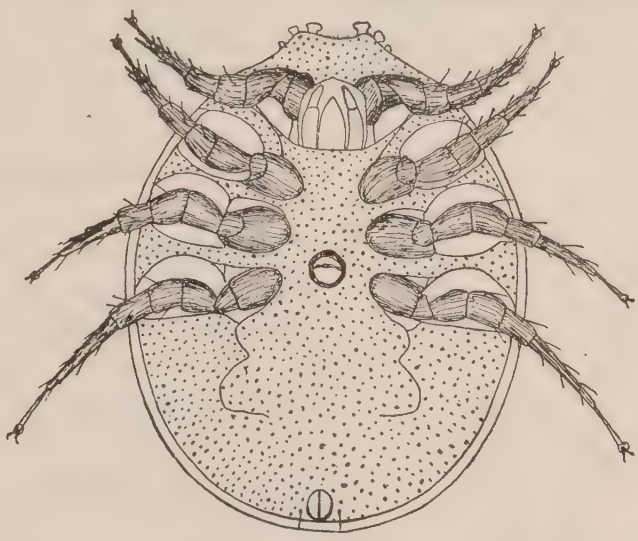


FIG. 175.— *Uropoda* sp., from below. (Author's illustration.)

some are smooth, others hairy; nearly all of a red-brown fawn color. The species of *Glyphopsis* have also been found in ants' nests, and seem to live on good terms with the ants, although their exact status is not known. One species, *G. michaeli* Ewing, is recorded from Illinois. It differs very little from *Trachyuropoda*. *Uroseius* and *Polyaspis* are based on a few forms, and not well known; a species of the latter genus has been found on *Orthosoma* in Ohio.

Trachytes contains two or three pyriform species found in moss. The genus was formerly called *Celaeno*. *Cilliba* is similar in appearance to *Uropoda*. Some species have been found in moss, but others occur parasitically upon ants, attached to the thorax or abdomen. One of our species, *C. circularis* Banks, has been found thus fastened to the thorax of *Cremastogaster lineolata*. Another species, *C. hirsuta* Banks (fig. 176), was taken upon a species of *Lasius* in Arizona.

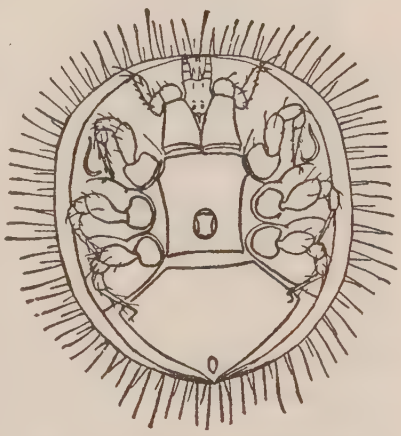


FIG. 176.— *Cilliba hirsuta* from below. (Author's illustration.)

The relation existing between the *Cilliba* and the ant has formed the subject of several recent investigations, both by Wasmann and by Janet. The mites which cling to the abdomen of the ant do not seem to be disturbed by the ant, but if a mite was placed on the ground of the nest it was seized and destroyed by the ants. The mites bite through the soft skin situated between the segments, and thus draw blood from their hosts.

The genus *Dinychus* (fig. 177) is peculiar in having enormously long extensile flexible mandibles. The mandibles are more than twice as long as the entire animal, and can be retracted so that the bend in them is close against the posterior walls of the abdomen. The tips of these mandibles are distinctly chelate. We have one species in this country.

From New Guinea, Canestrini has described several species of a remarkable genus— *Deraiophorus*. They have a pair of plate-like projections over the head, and from these

arise long bristles, and there are also bristles at tip of abdomen. Two other genera, *Uropodella* and *Fedrizzia*, have been described from tropical countries.

The species of *Trachyuropoda* are quite variable in appearance, but all have the body longer than broad, with a dorsum showing pits around the edge or else a median depression, or scars, or pits. In many forms the anterior part of the body is narrowed and projects forward as a hood over the mouth parts; the margin of the body is often lobed or crenulate; the legs are very short. Several species have been found in the nests of various ants, and they doubtless feed on decaying matter therein. Berlese has divided it into several subgenera, according to the shape and sculpture of the dorsum.

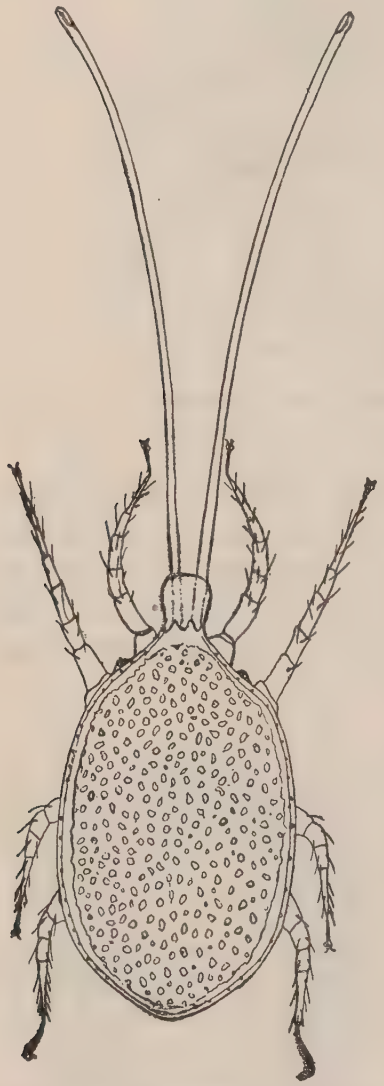


FIG. 177.—*Dinychus americanus*. (Author's illustration.)

Superfamily ORIBATOIDEA.

The oribatid mites may usually be recognized by the presence of a single character—a hair or seta arising from a small pore near each posterior corner of the cephalothorax. This pore was formerly considered a spiracle, but it is now known not to be such an organ. Its function, however, is uncertain, and it is called a pseudo-stigma, while the hair arising therefrom is known as the pseudostigmatic organ (fig. 178).

With the great majority of the Oribatidæ the tegument is coriaceous; it is because of this that these mites have been called "beetle mites." This name is somewhat misleading, as members of another family, Parasitidæ, are often attached to beetles, and therefore sometimes termed "beetle mites."

The body of an oribatid is short, broad, and usually high. There is always more or less indication, usually very plain, of the division into cephalothorax and abdomen. There is at this point a constriction on the sides, a line or suture on the venter, and a break in the continuity of the dorsal outline. The posterior pairs of legs are apparently attached to the abdomen. The coxæ of the legs are arranged in a somewhat radiate manner, and the hind pairs are never remote from the anterior pairs. Each leg is composed of six joints, namely, coxa, trochanter, femur, patella, tibia, and tarsus. Sometimes there is a plate-like expansion near the base of the coxæ, known as a "tectopedium." The coxæ are usually entirely united to the ventral surface of the body to form a sternal, or, more properly, a coxal plate, each coxa usually being margined by a short furrow. In *Nothrus*, however, the coxæ may be seen to be quite distinct from the body. On the first two pairs of legs the trochanter is extremely small and usually indistinct, while this joint is often very large on the hind pairs. So it follows that the hind legs have, apparently, one more joint than the front pairs. The tarsus is terminated by one or three claws, but without a sucker or pulvillus. The legs bear a few hairs, but never many; one at the tip of the tibia is often much longer than the others. The tarsus is commonly more hairy than the other joints.

On the dorsum of the cephalothorax there are often narrow ridges or lamellæ; the position, shape, and development of these being characteristic of each species. Generally there is an erect lamella each side, extending in a point (sometimes bifid) in front of the cephalothorax. Frequently there is a translamella connecting the lateral lamellæ. There are also on the cephalothorax usually two pairs of bristles; the pair near and

between the pseudostigmata are the superior bristles; the pair toward the tip and often at ends of the lamellæ are the inferior bristles. There is also a pair of smaller bristles at the apex of the cephalothorax. Around the sides of the abdomen there is a line separating the dorsum from the venter. In the Hoplodermidæ this line is often far down on the under side of the body. The dorsum of the abdomen is often devoid of hairs, but sometimes there are a few, usually arranged in rows. In many common species there is a membranous expansion each side at base of the abdomen, called pteromorphæ or wings. On the venter are two openings, the basal the genital one as usual. These openings are circular, elliptical, or rhomboidal, and are closed by folding doors opening outward, and hinged to the outer margins of the apertures. In many forms these apertures are very large and occupy the greater part of the venter; in other and more highly organized species the openings are much smaller and quite remote from each other.

FIG. 178.—Leg, mandible, and pseudostigmatic organ of an oribatid. (Author's illustration.)

The mouth parts (fig. 179) of the Oribatidæ are obscure. The palpi are very small, five-jointed, and arise from the labium. They are usually in motion while the mite is walking. The mandibles are chelate in all save the genus *Serrarius*. The limbs of the chelæ are commonly toothed on the inner sides. In *Serrarius* the mandibles are elongated and rodlike, and there is no movable limb at tip; the edges being serrate, so that the mandibles act as a saw. The maxillæ have their basal joints united into one transverse piece, the labium, which partly and sometimes wholly closes the mouth orifice. The maxillæ incline slightly toward each other; their tips are broad and toothed. The Oribatidæ deposit their eggs in crevices of wood, moss, or fungi, or on the ground. Their eggs are often elliptical, or cylindrical, with rounded ends. Sometimes the surface is roughened and granulated. The six-legged larva remains for a few weeks in this stage, when, by a molt, it becomes an eight-legged nymph. The nymph passes through three molts, increasing in size at each, the third molt bringing it to the adult condition. In some cases the eggs are not deposited, but ripen in the body of the parent mite; the mother then dies and dries up, her old shell remaining as a protection for the eggs till they hatch. Other species have eggs with a dark brown or chitinized shell, which is perforated with very minute pores. As the inclosed larva develops the outer shell splits, showing the white vitelline membrane encircling the egg; this stage is the deutovum. The eggs of some genera bear lateral processes, and are deeply sculptured in elaborate patterns. The larvæ are all monodactyle, and have a soft skin with but little color. The nymph (fig. 181) is also monodactyle; its skin is soft or leathery, or sometimes chitinized toward

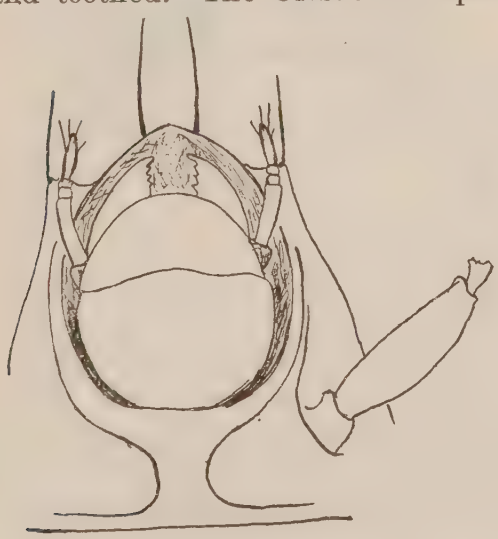


FIG. 179.—Mouth parts of an oribatid from below. (Original.)

the last. There are few creatures more bizarre or remarkable than the nymphs of certain Oribatidæ. Some bear upon the back concentric rings of beautifully iridescent, membranous, fan-shaped scales (fig. 189). Others carry a collection of their molted

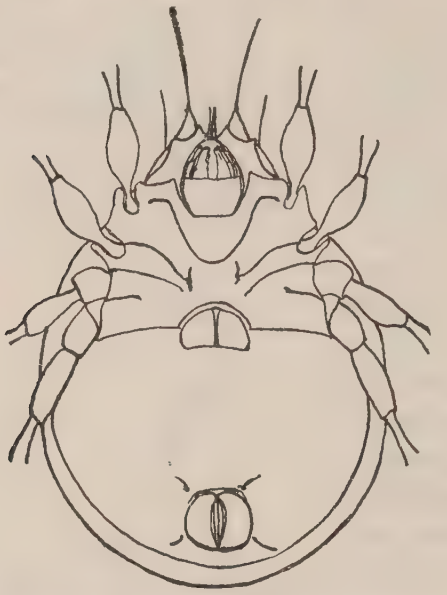


FIG. 180.—*Galumna* sp., from below. (Author's illustration.)

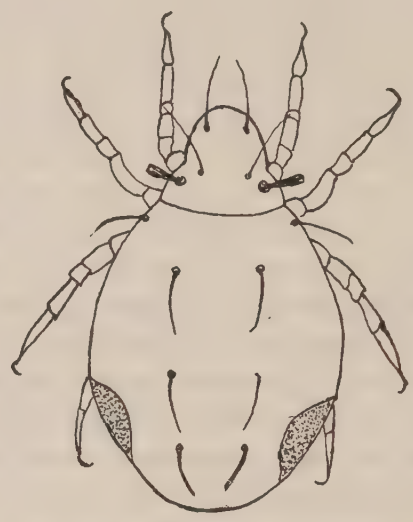


FIG. 181.—Nymph of a *Galumna*. (Author's illustration.)

skins, eggshells, bits of dirt, moss, etc.—a veritable peddler's pack of trash. Many species have rows of serrate hairs on their backs. The skin of the back of many nymphs is wrinkled so as to allow for growth. Many of these nymphs were described by early writers on acari as distinct species, or even genera.

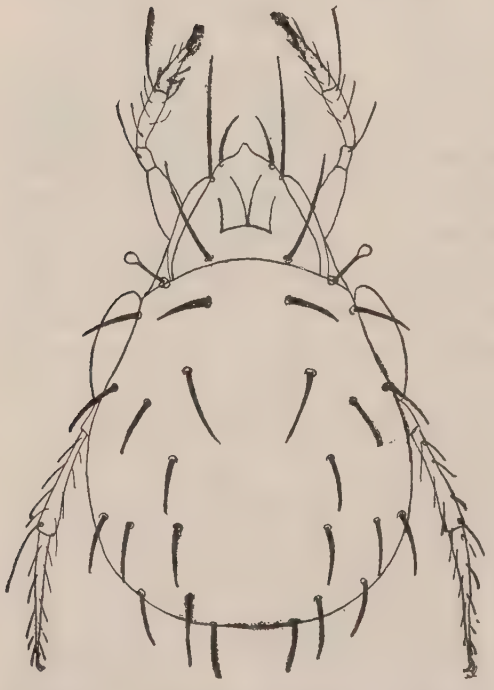


FIG. 182.—*Galumna hubbardi*. (Author's illustration.)

FIG. 183.—*Galumna persimilis*. (Original.)

The nymphal period is the most important in the life of these mites; it is the time of growth, of adaptation to its environment, and often of bright coloration. Some species have the body a clear pink, crimson, delicate green, or golden yellow; in many forms there is a large dark brown or black spot behind at each side. Those species

that bore in decaying wood are usually a milky or yellowish white. While in the nymphal stage the mite undergoes three molts; the last molt bringing it to the adult condition. In some cases the nymph during the latter part of its life approaches the appearance of the adult; in other species the nymph at each molt becomes more and more specialized, and in no wise approaching the adult in appearance. The hairs are often very long, frequently serrate, and sometimes scalelike and even fan-shaped. In several cases of allied species the nymphs are similar in appearance, while the adults are very dissimilar.

When a nymph is about to become an imago it seeks some sheltered spot and, fixing its legs firmly in the substance upon which it rests, it gradually becomes inert and apparently dead. It remains in this condition about 10 days. When about to transform to the adult the skin splits behind and shows the imago beneath; this split increases without any perceptible movement of the mite until it is quite large, when the mite begins to back out of its old shell. It may be noticed then, according to Michael, that the legs of the adult are not withdrawn from the legs of the nymph, but are folded beneath the adult. It may be, however, that they had been withdrawn from the nymphal legs before the skin begins to split. Once out, the mite walks off, leaving its old skin with the legs outstretched in the position they had during the resting stage. Nymphs can live over the winter, and while they are most abundant in spring, they are also found at other times. Michael, who has reared many oribatids, thinks that the winter is usually passed in the egg or adult stage, and that there may be several but no regular number of broods each year.

FIG. 184.—*Oribatella valida*. (Original.)

Some species (*Ameronothus*), it is claimed, are viviparous, Bostock having observed the birth of living larvæ. These forms occur in water, and the aquatic habit has, perhaps, something to do with their viviparity.

Many of the oribatids have a general resemblance to tiny beetles, and are often taken by coleopterists in the field for them. One species, *Notaspis castaneus* Herm., deceived Robineau-Desvoidy, who described it as a new genus and species of beetle—*Xenillus clypeator*.

The internal anatomy of the Oribatidæ is quite well known, having been investigated by Nicolet, and later and more thoroughly by Michael. The alimentary canal is composed of a pharynx, œsophagus, stomach or ventriculus, intestine, colon, and rectum. The œsophagus has, near its posterior part, an enlargement or ingluvies of varying size, according to the species. The stomach is a large sac in the upper part of the abdomen, provided with two large cæca, one each side, reaching back to near the tip of the abdomen. The small intestine is very short and enlarges to the colon, which is separated from the rectum by a constriction. In most, if not all, forms there are two large glands, the proventricular glands, which open into the ventriculus near the cæca. They are supposed to secrete some fluid useful in digestion. The male organs of generation consist of one central testis, usually large, two vasa deferentia, uniting into a ductus ejaculatorius, which opens through an extensile penis. In the female there is a median ovary (sometimes showing traces of division) opening into two oviducts which unite in a vagina; the latter opens through a protrusible ovipositor. It is possible that the ovary is connected by two fine tubes to an aperture near the anus,

and that this is the bursa copulatrix. Coition, however, has not been observed, so it is not certain that the male does not use the vagina.

FIG. 185.—*Oribatella armata.* (Author's illustration.)

The tracheæ when present vary much in shape and size. They open at the acetabula of the legs; one or two tracheæ proceed from each acetabulum; sometimes they are very long and wind about in the body; sometimes short, and again they may be enlarged to form air sacs. In *Hoploderma* there are no tracheæ and in *Nothrus* they are rudimentary, and they are lacking in the larvæ and nymphs of all forms. There are various excretory organs; one pair, the supercoxal glands, open near the acetabula of the second legs; others, the expulsory vesicles, open on the sides of the abdomen. The Oribatidæ have a delicate sense of touch, which resides apparently in the long hairs or setæ upon the legs, particularly a very long hair on the tibia. They have no eyes, yet have a quick appreciation of light and darkness, and prefer the latter. It is quite possible that the pseudostigmata are organs of hearing.

The food of the Oribatidæ is usually of a vegetable nature, but a few species affect decaying animal matter; one of our common species is usually found on bones. Many feed on lichens and fungi, and some bore into decaying wood. Several kinds are found on the bark of living trees, and others under dead bark. Many species occur in moss, but do not necessarily feed upon it. None of them is parasitic in any stage. Most species are slow in traveling, and often, when disturbed, feign death. Some of the adult mites, as stated, carry their molted skins and other rubbish on their backs.

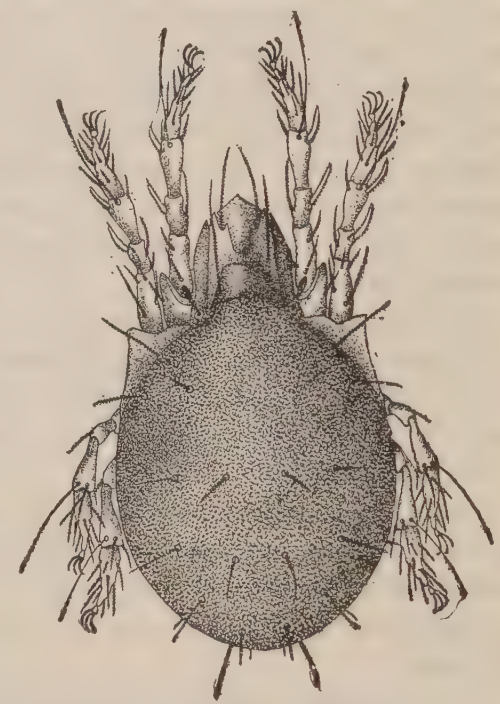


FIG. 186.—*Oribatella* sp. (From Marlatt.)

Practically none of the Oribatidæ is of economic importance. A few have been recorded as damaging grass, and one (*Liacarus capitatus* Banks) occurs in immense numbers in wheat fields of Kansas and Oklahoma; but as a whole they probably are slightly beneficial. There are doubtless 400 species of this family in the United States, for about 250, mainly from the Eastern States, have been described. On account of their minute size, obscure habits, and small economic value they are not favorites with collectors, but their complexity of structure furnishes more characters for classification than in the case of other acari.

The superfamily Oribatoidea contains three distinct families; some writers have split it up into six or more, but on characters of minor importance.

1. Mandibles very large and prominent; no division between cephalothorax and abdomen; two claws to front tarsi, three claws to other tarsi..... LABIDOSTOMMATIDÆ

Mandibles small or inconspicuous; a line between cephalothorax and abdomen; claws alike in number on all legs 2

2. Cephalothorax movably attached to the abdomen; palpi four-jointed; no chitinous sternum, and venter narrow ..... HOPLODERMATIDÆ

Cephalothorax not movable; palpi five-jointed; a chitinous sternum; venter broad ..... ORIBATIDÆ

FAMILY ORIBATIDÆ.

In the true Oribatidæ there are a great many genera, and there appears to be much doubt as to the proper names of several of them, owing to the work of old authors who had no idea of the rules of modern nomenclature.

Oudemans and several other acarologists have arranged the oribatid mites in seven or more subfamilies, based largely on the presence or absence of the "wings" or pteromorphæ, the existence of strong cephalic lamellæ, and the thickness of the legs. The development of the pteromorphæ is very gradual, and there are plenty of living representatives whose pteromorphæ are so small as to make the character an uncertain one. The same may be said of the legs, there being many gradations between the very slender and the thick and roughened ones. Differences in these points are, therefore, of hardly generic value. The better-known genera are in the following table:

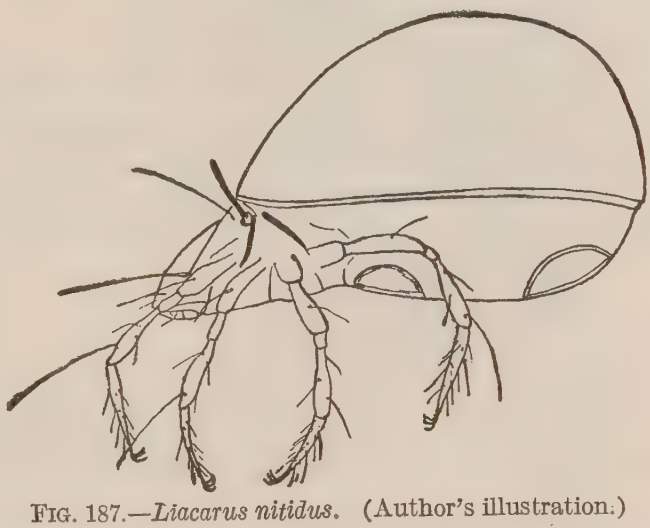


FIG. 187.—*Liacarus nitidus*. (Author's illustration.)

1. Abdomen with winglike expansions at the anterior sides 2
   Abdomen without such expansions 8
2. Superior bristles spatulate; three claws to each tarsus ..... *Pelops.*
   Superior bristles not spatulate 3
3. The wings attached to the cephalothorax as well as to the abdomen, at least apparently so 4
   The wings attached apparently only to the abdomen 6
4. Tarsi I and II broad at tips; three claws to each tarsus 5
   Tarsi I and II tapering to a point; one claw to each tarsus; no suture between cephalothorax and abdomen ..... *Tectocepheus.*
5. Tarsus II very short, broad, cup shaped ..... *Oripoda.*
   Tarsus II slender, not cup shaped ..... *Gymnobates.*
6. One claw to each tarsus ..... *Oribatodes.*
   Three claws to each tarsus 7
7. Lamellæ very large and prominent, attached to the cephalothorax for only a part of their length ..... *Oribatella.*
   Lamellæ smaller, attached to the cephalothorax for their entire length ..... *Galumna.*
8. Cephalothorax with lamellæ 9
   Cephalothorax without lamellæ 17
9. With one claw to each tarsus; tibia pedicellate 10
   With three claws to each tarsus 11
10. Body smooth above ..... *Oribella.*
    Body more or less sculptured or roughened above ..... *Carabodes.*
11. Legs II, III, and IV arising from well beneath body 14
    Legs II, III, and IV arising from near edge of body 12
12. Trochanter III with a very long, prominent bristle; abdomen smooth ..... *Notaspis.*[1]
    No long bristle on trochanter III 13
13. Lamellæ submedian; tibiæ much longer than the tarsi ..... *Eremaeus.*
    Lamellæ sublateral; tibiæ but little longer than the tarsi ..... *Oribatula.*

[1] Type is *N. bipilis* Herm., fixed by Nicolet; Hermann gave no type.

14. Mandibles long and slender, serrate at tips, extensile; ventral apertures far apart ..... *Serrarius.*
Mandibles normal, chelate 15
15. Cephalothorax and abdomen joined by a median piece; tibiæ I and II not pedicellate; lamellæ projecting in front of head ..... *Scutovertex.*
Cephalothorax and abdomen separated by a continuous line; all tibiæ pedicellate 16
16. Abdomen smooth ..... *Liacarus.*
Abdomen more or less sculptured ..... *Banksia.*
17. One claw to each tarsus 18
Two claws to each tarsus ..... *Eulohmannia.*
Three claws to each tarsus 24
18. Tectopedia present, legs very long 19
Tectopedia absent, legs short 21
19. Cephalothorax and abdomen not separated in the middle; the ventral apertures far apart ..... *Amerus.*
Cephalothorax and abdomen separated by a continuous line 20
20. Ventral apertures far apart (more than their diameter) ..... *Oppia.*[1]
Ventral apertures approximated ..... *Oribata.*
21. Abdomen with the anterior lateral parts separated by sulci from rest of the dorsum ..... *Trizetes.*
Abdomen with transverse sulci ..... *Hypochthonius.*
Abdomen entire, no sulci 22
22. Ventral apertures contiguous ..... *Lohmannia.*
Ventral apertures separated 23
23. Body more or less sculptured; some joints of legs pedicellate ..... *Hermannia.*
Body not sculptured; no joints pedicellate ..... *Malaconothrus.*
24. Legs very slender, much longer than body; ventral apertures approximate ..... *Damaeus.*
Legs shorter or barely longer than body 25
25. With tectopedia 26
Without tectopedia 27
26. Abdomen deeply sculptured above ..... *Cepheus.*
Abdomen not sculptured, concave ..... *Plateremaeus.*
27. Cephalothorax and abdomen united above, no suture ..... *Ameronothrus.*
Cephalothorax and abdomen well separated above 28
28. Abdomen hard, with concentric rings ..... *Neoliodes.*
No such concentric rings 29
29. Abdomen soft, convex, with more or less distinct transverse lines; ventral area very narrow ..... *Tripochthonius.*
Abdomen more coriaceous, flat; no transverse lines; venter broad ..... *Nothrus.*

Most of the common forms belong to either *Galumna* (figs. 180, 181) or *Oribatella* (fig. 186). They are usually shining black in color, sometimes with a pale spot at base of abdomen, and rarely with hairs or bristles above. They have the anterior sides of the dorsal integument extended downward in a winglike expansion. The shape of this "wing" is characteristic in each species. Many species can be sifted from moss. They at first remain quiescent but after a few moments start to crawl away.

G. hubbardi (fig. 182) occurs in Florida; *G. pratensis* Banks may be swept from meadows in great numbers and doubtless injures grass to some extent. *O. aquatica* Banks lives on aquatic plants and can easily walk on the surface of stagnant water, yet there seems to be nothing peculiar in the structure of the tarsi. *G. arborea* Banks and *G. affinis* Banks occur on the bark of trees. *G. hirsuta* Banks is a pale yellowish form, with a bristly body, occurring in dry sandy places. *O. angusta* Banks has been taken from the nest of a Texas ant. In *O. armata* Banks (fig. 185) the wing is provided with a long spinelike process. *G. emarginata* Banks has the wings emarginate beneath and radiately marked; it is widely distributed in the Eastern States, and very common under rubbish and in moss.

G. persimilis Banks (fig. 183) occurs in the White Mountains and *O. valida* Banks (fig. 184) in Virginia. Some species cluster for hibernation and may be found in

[1] Type is *O. nitens* Koch, thus replacing *Damaeosoma.*

FIG. 188.—*Liacarus carolinensis.* (Original.)

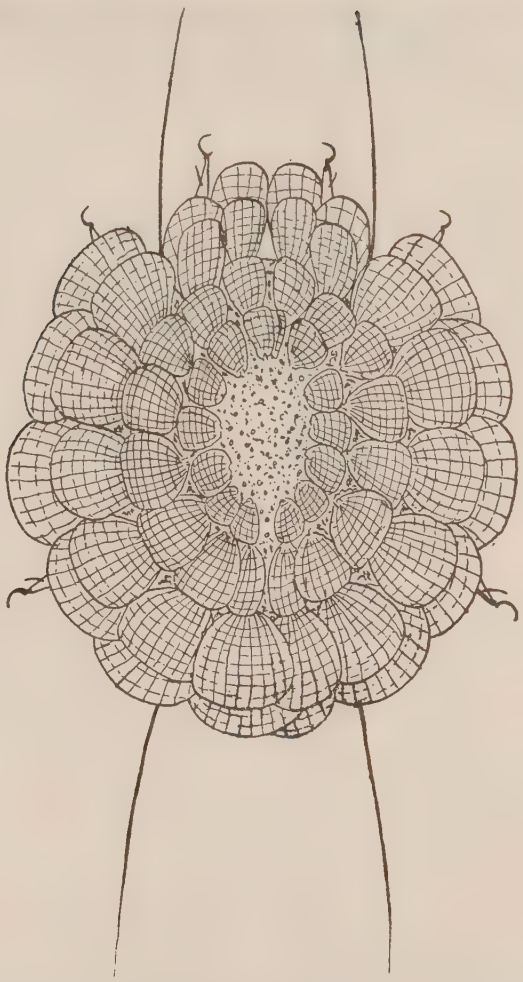


FIG. 189.—*Liacarus* sp.: Nymph. (Author's illustration.

FIG. 190.—*Oribella pilosus.* (From Marlatt.)

FIG. 191.—*Notaspis montana.* (Original.)

numbers during the winter under stones or bark of dead trees. *Gymnobates* (fig. 192) and *Oripoda* (fig. 193) are rare forms with very short, blunt tarsi.

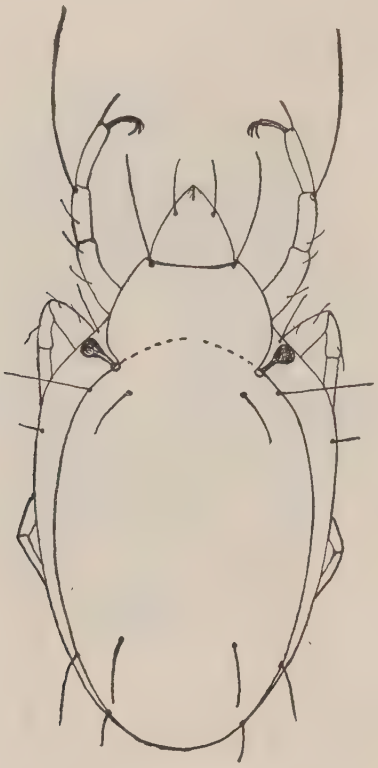


FIG. 192.—*Gymnobates glaber.* (Author's illustration.)

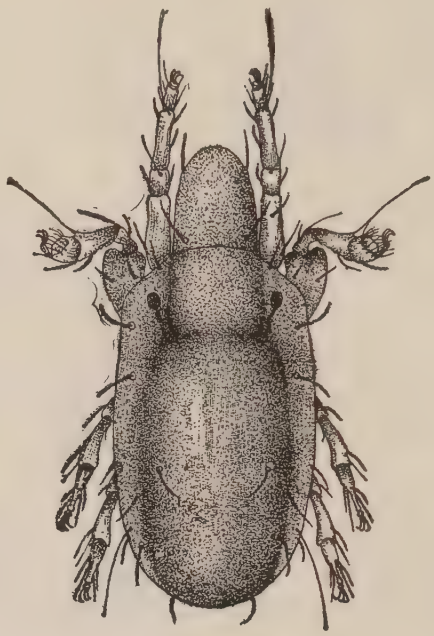


FIG. 193.—*Oripoda elongata.* (From Marlatt.)

The genus *Pelops*, closely related to *Galumna*, has several species in this country; they have been found in moss, but are uncommon; a European species is frequent on oak leaves. One of the most common forms and one of the largest of the family, being fully 1 mm. long, is *Liacarus nitidus* Banks (fig. 187). It occurs on the ground under pieces of wood, bark, stones, and fallen leaves. Another species, *L. carolinensis* Banks (fig. 188), has a more elongate body. A species of *Oribella*, *O. pilosus* Banks (fig. 190), is common in the crevices of bark of living trees. There are four rows of bristles on its abdomen. *O. modestus* Banks occurs on the bark of walnut trees in California. To *Notaspis* (fig. 191) belong species with a few long bristles.

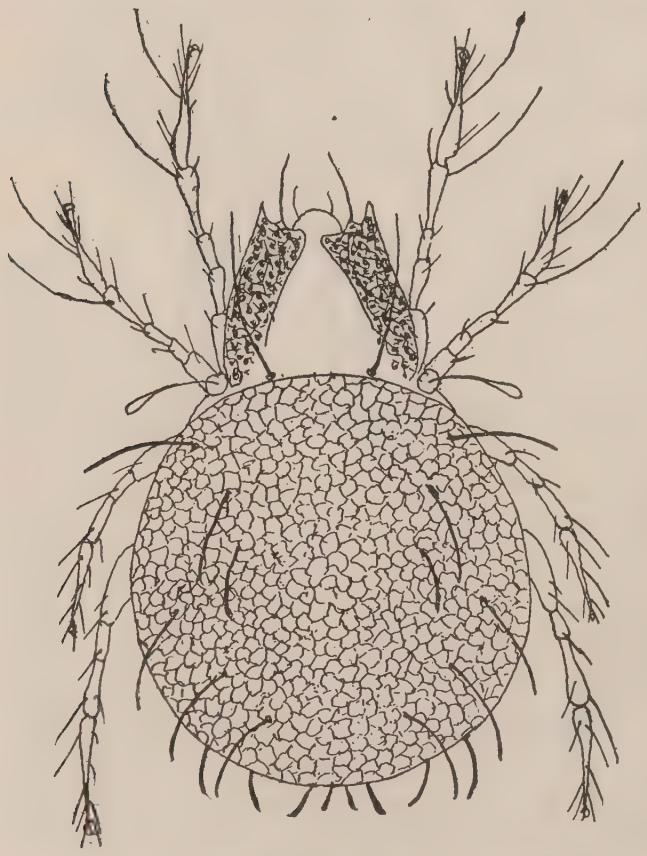


FIG. 194.—*Carabodes lamellatus.* (Original.)

A species of *Scutovertex*, *S. marinus* Banks, is not uncommon on rocks between tide marks on the Atlantic seashore. It appears to lack the pseudostigmatic organs and is otherwise peculiar. Another species, *S. petrophagus* Banks (fig. 202), forms little cavities on the limestone rocks of waterfalls in central New York; one mite dwells in each cavity. The process by which the cavity is made is unknown, but possibly by the aid of some secretion of the mite. Of *Carabodes* (figs. 194, 200) we have

several species, some of which are found in fungi. Our most abundant species, *C. niger* Banks, which occurs in fungi, has four rows of spatulate hairs on the dorsum.

C. oblonga Banks was found under the bark of a stump, and it looks much like a tiny scolytid beetle.

The typical genus *Oribata* (figs. 196, 197, 198) includes many nearly smooth species with slender legs. One species, *O. minuta* Banks (fig. 199), occurs abundantly in moss and on decaying animal substances. It is pale yellowish brown in color and appears to be widely distributed. Other species of *Oribata* (fig. 195) occur among dead, dry leaves, and can run very rapidly. The nymphs are soft, whitish creatures with long hairs, and often carry bits of dirt attached to the hairs. Under the name *Tumidalvus*

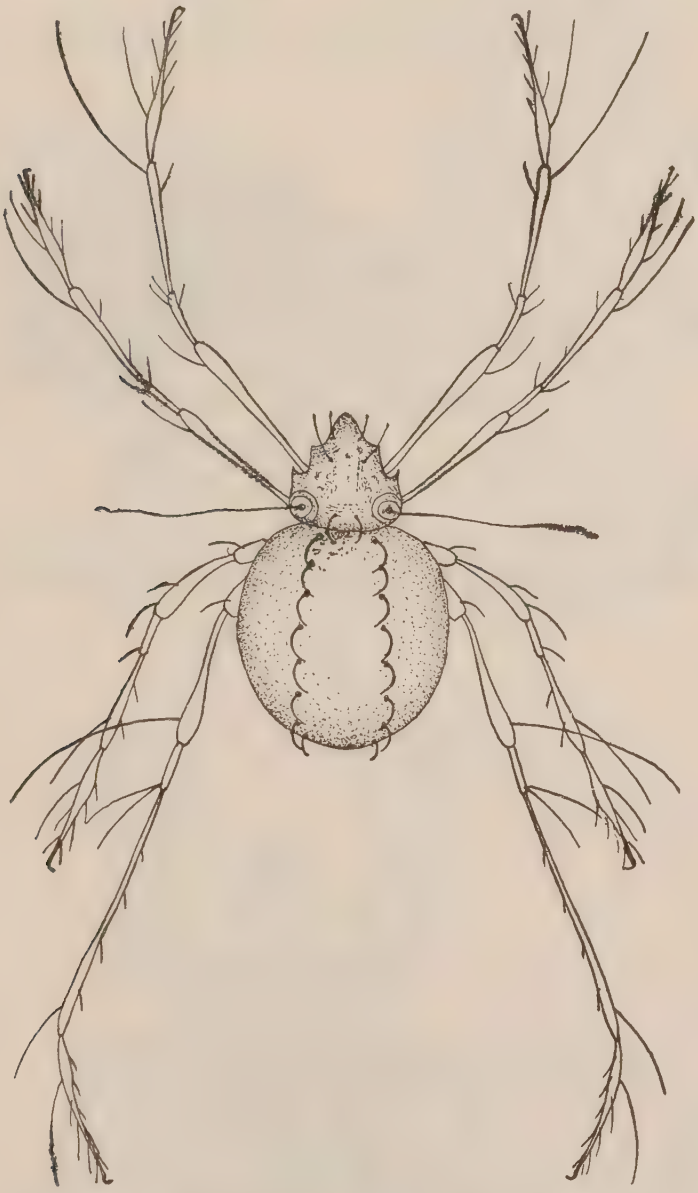


FIG. 195.—*Oribata gracilipes.* (Author's illustration.)

FIG. 196.—Venter of *Oribata.* (Author's illustration.)

americana Ewing has described a species of *Tripochthonius* from Illinois. At the tip of the body is a rounded swelling, and the long, stout bristles of the body are minutely hairy. The largest oribatid we have is *Neoliodes concentricus* Say (fig. 203), a black species with concentric rings on its elevated abdomen. It occurs in crevices of bark of living trees throughout the Eastern States, and also in Europe. One species of *Cepheus*, (*Cymberemaeus*) *C. marginalis* Banks (fig. 201), occurs under lichens on the bark of trees in the Eastern States. The type of this genus is *C. minutus* Koch, *C. latus* Koch having been removed as the type of *Tegeocranus.*

We have various species of *Nothrus* (fig. 204), or *Camisia*, as it may have to be called. They are very rough-looking creatures, with a squarish body and short, rough legs.

N. truncatus Banks (fig. 206) occurs in sphagnum moss and on the ground in wet fields. *N. excisus* Banks occurs on the bark of spruce trees, where it is much protected by its color. Another species, *N. simplex* Banks, was found among lichens on dry rocks.

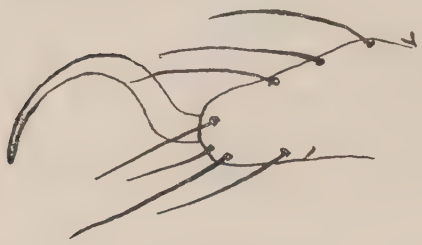


FIG. 197.—Claw of an *Oribata*. (Author's illustration.)

FIG. 198.—Larva of an *Oribata*. (Author's illustration.)

FIG. 199.—*Oribata minuta*. (Author's illustration.)

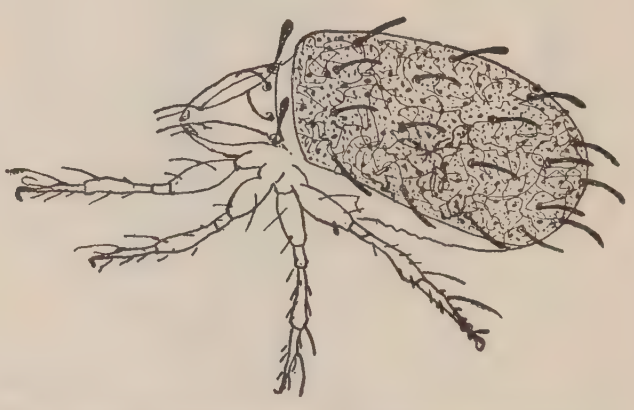


FIG. 200.—*Carabodes brevis*. (Author's illustration.)

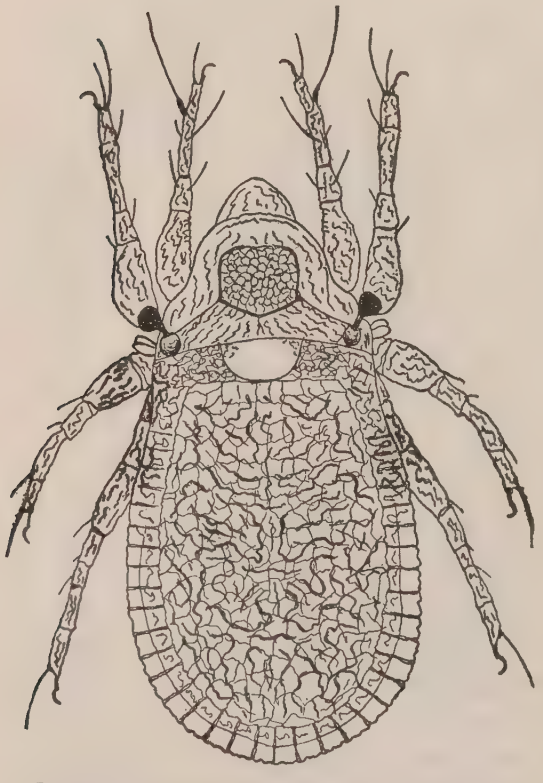


FIG. 201.—*Cepheus marginalis*. (Author's illustration.)

FIG. 202.—*Scutovertex petrophagus*. (Original.)

N. rugulosus Banks is a common form under loose bark; it can scarcely be distinguished from the bits of dirt among which it lives. *N. taurinus* Banks (fig. 207) is a common eastern form, and *N. banksi* Michael (fig. 205) occurs in the Western States.

They are very sluggish in their movements, and if disturbed will remain motionless for 15 minutes or more. Several species cover their abdomen with bits of dirt. The nymphs have a considerable resemblance to the adult, and have frequently been described as

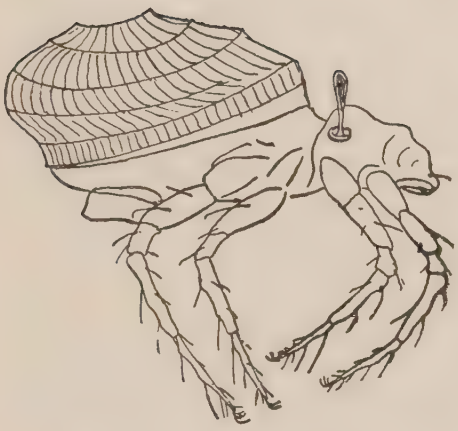


FIG. 203.—*Neoliodes concentricus.* (Author's illustration.)

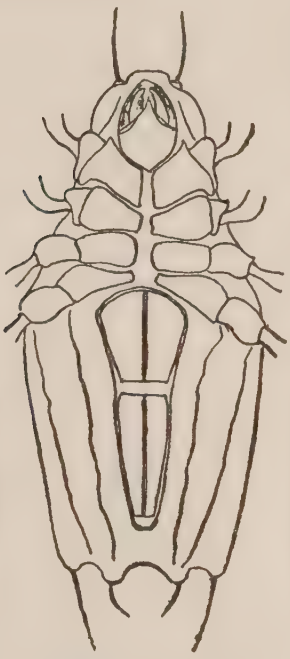


FIG. 204.—Venter of a *Nothrus.* (Author's illustration.)

FIG. 205.—*Nothrus banksi.* (Author's illustration.)

FIG. 206.—*Nothrus truncatus.* (Author's illustration.)

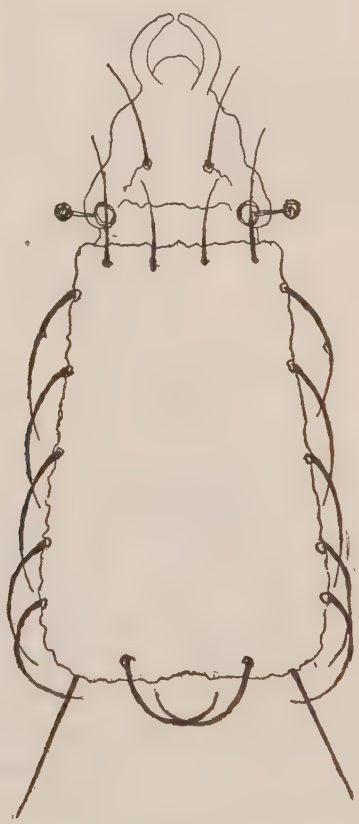


FIG. 207.—*Nothrus taurinus.* (Original.)

mature mites. Quite a number prefer aquatic or semiaquatic situations, and probably feed on the aquatic vegetation. The species of *Hypochthonius* look like nymphs, and have a soft skin and monodactyle claws; the segmented abdomen separates the genus from allied forms. *H. texanus* Banks (fig. 208) occurs in the nest of a Texas ant;

others are found in moss or on damp soil. Berlese has divided the genus into several; one of them, *Trizetes*, appears to be very distinct. Of *Hermannia* we have several species, mostly in the north; some have a curious, campanulate process on each side of the body. In recent years Berlese has described many remarkable exotic forms in several new genera.

FIG. 208.—*Hypochthonius texanus.* (Original.)

FAMILY HOPLODERMATIDÆ.

The Hoplodermatidæ are separated from the genuine Oribatidæ in having the cephalothorax movably attached to the abdomen. By this means the animal is able to roll up, concealing the legs. The legs of the Hoplodermatidæ are attached to the body close together, and the whole sternal structure is soft and membranous, instead of coriaceous, as in the Oribatidæ. The palpi are four-jointed. The dorsal plate of the abdomen extends down upon the sides, so that the venter is very narrow and almost wholly occupied by the large genital and anal apertures. *Phthiracarus glabrata* Say is one of our largest and most common forms, and is found on moist ground. The species of *Hoploderma* are most common in decaying wood or moss. When disturbed they roll up, "play possum," and are then not easily discerned. One of the species described by Riley was supposed to feed on the *Phylloxera*, but such is not the case, its food evidently being decayed vegetable matter. The young occur in the same localities as the adults. The nymph is a soft, yellowish-white creature, not unlike a *Tyroglyphus*. They have long mandibles, and can not fold up like their parents. Our forms have been described in

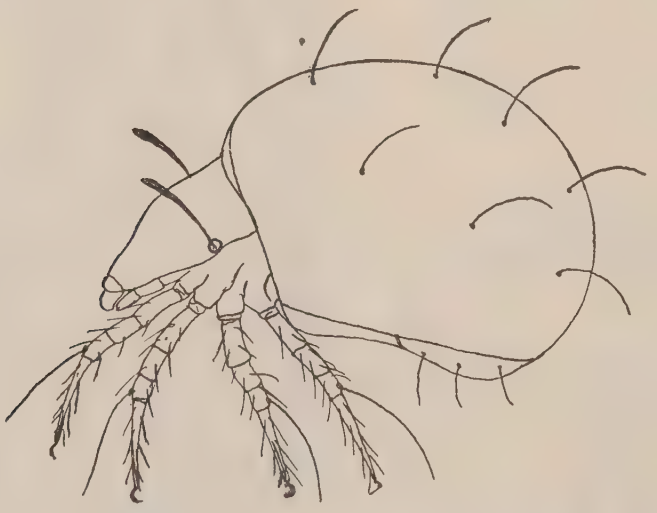


FIG. 209.—*Hoploderma sphaerula.* (Author's illustration.)

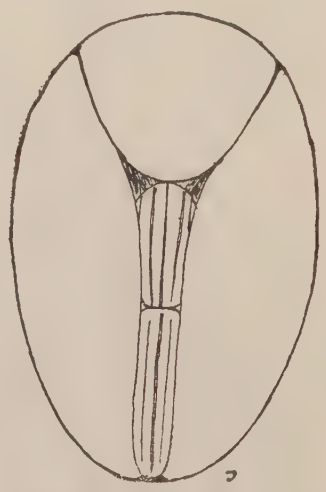


FIG. 210.—*Phthiracarus* sp., closed up; ventral view. (Author's illustration.)

Hoploderma (*Hoplophora*) and *Phthiracarus* (*Tritia*) (fig. 210), but various other genera are known; the principal ones may be grouped as below:

1. Posterior part of abdomen segmented; one claw to each tarsus.....*Protoplophora.*
   Posterior part of abdomen not segmented.....2
2. Ventral apertures distinctly separated; ventral area rather large....*Mesoplophora.*
   Ventral apertures nearly or quite contiguous.....3

3. One claw to each tarsus; ventral apertures slightly separate.....*Hoploderma.*
   Three claws to each tarsus; ventral apertures contiguous.....*Phthiracarus.*

Most of our species, as *H. sphaerula* (fig. 209), have a smooth, shining dorsum, with a few hairs; but one species, *H. granulata* Banks, has a very rough dorsum. The characters of the species are not as easily observed as in Oribatidæ, and there appears to be considerable variation in size in the same species.

Family LABIDOSTOMMATIDÆ.

This family contains but one genus, *Labidostomma* (figs. 211, 212), a few species of which are found in Europe, Central America, and Oregon in fields or among fallen

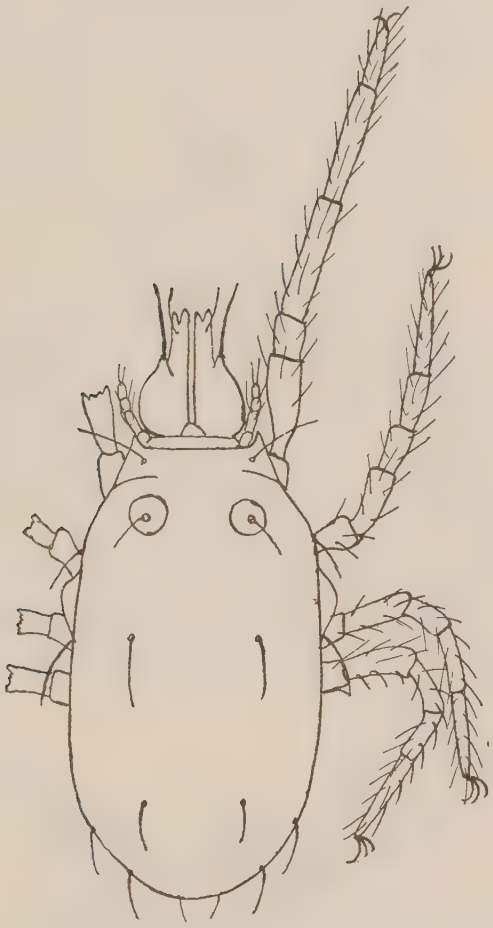


Fig. 211.—*Labidostomma cornuta.* (Original.)

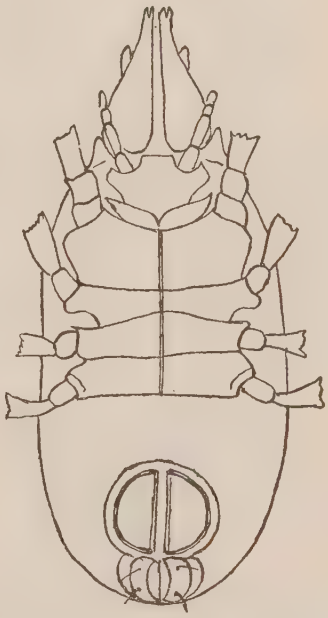


Fig. 212.—*Labidostomma cornuta*, venter. (Original.)

leaves. The mandibles are very large and prominent; the coxæ are all approximated; the tarsus I is short and ends in two claws, while the other tarsi are much longer and end in three claws. The genital and anal apertures are large and close together. The body is rather elongate, depressed, yellowish in color, and without eyes. Their general appearance is that of a *Parasitus*, but their structure shows they are closely related to the Oribatidæ. Trouessart put them in the Gamasidæ, Canestrini and others have placed them in the Oribatidæ, Oudemans made a family for them, and some think they should form a separate suborder—Stomatostigmata. They were first described by Von Heyden as *Panoplia*, and later by Canestrini as *Nicoletia*, both names being preoccupied; *Labidostomma* of Kramer is available; later Canestrini proposed *Nicoletiella*, and this name is used by some writers. Ewing described our one species as a new genus, *Ceratoacarus*. The few known species show more or less plainly a pit on each side of the cephalothorax, from which arises a hair or bristle; but it is doubtful if this is homologous with the pseudostigmatic organ of the Oribatidæ. Their habits and immature stages are unknown. Oudemans has found that

the stigmata are on the underside of the mandibles. He also found living unhatched eggs within the body of the dead mite. Similar cases are known in the Oribatidæ.

Superfamily SARCOPTOIDEA.

Family TARSONEMIDÆ.

This is a small family, but of much biological and economical interest. They are soft-bodied mites and in some ways resemble the Tyroglyphidæ, but the females differ from them, as well as from all other Acarians, in having between legs I and II a prominent clavate organ of uncertain use. The mouth parts (fig. 213) are formed for sucking, and the mandibles are very slender and needle-like. The palpi are minute and barely visible. There are tracheæ which open on the ventral surface near the base of the rostrum. The legs are short and composed of five or six joints; the anterior tarsi terminate in one claw, the others usually have two claws and often a sucker. The posterior pairs of legs are quite remote from the anterior pairs; in the males of *Tarsonemus* they are almost at the tip of the body. In some species the abdomen shows traces of segmentation by the presence of a few transverse lines on the dorsum. The anal opening is at the end of the body. The genital opening in *Tarsonemus* is a small, elongate aperture near the hind coxæ. The body and legs are provided with a few simple hairs. In several genera of the family, notably in *Tarsonemus*, there is a marked difference in the structure of the

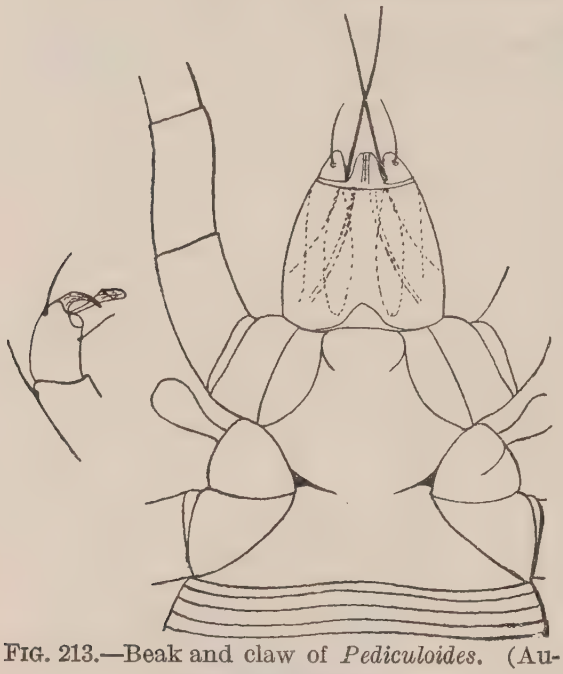


Fig. 213.—Beak and claw of *Pediculoides*. (Author's illustration.)

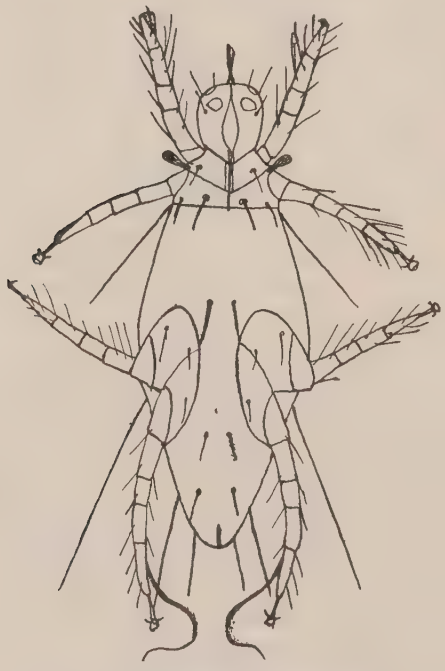


Fig. 214.—*Pediculoides ventricosus:* Female. (Author's illustration.)

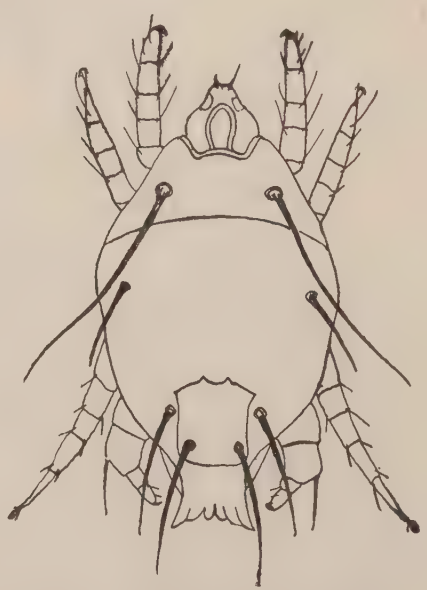


Fig. 215.—*Pediculoides ventricosus:* Male. (Author's illustration.)

sexes. In the male *Tarsonemus* the body is much shorter than in the female, and the hind legs are thick and heavy and end in a very large claw. In the female the hind legs are very slender and delicate, and terminate in two long hairs, one of them often as long as the entire leg. In the mature female of *Pediculoides* (fig. 216) the abdomen

becomes enormously swollen, so that it is 20 to 100 times greater than the rest of the body, the whole animal appearing as a white spherical grain, with a tiny scar on one side. The male of *Pediculoides* (fig. 215) has almost no abdomen at all, the body being very short, and angulate behind. The head in this genus is almost a distinct portion of the body. Brucker has studied the anatomy of *Pediculoides*. There is a large stomach, connecting to the mouth by a slender œsophagus; to the latter is attached a blind pharynx. He found no anus (but I believe one exists in *Tarsonemus*), the intestine ending blindly near the tip of the body. The genital opening is at the tip of the body; above it is a short spermatheca. In the females there are a pair of air reservoirs in the front part of the body; behind them are tufts of tracheæ, which, when the female becomes swollen by eggs, extend into the swollen part.

The Tarsonemidæ have not long held any one position in the system of Acarina. They have been associated with Oribatidæ by several writers, and Berlese has recently

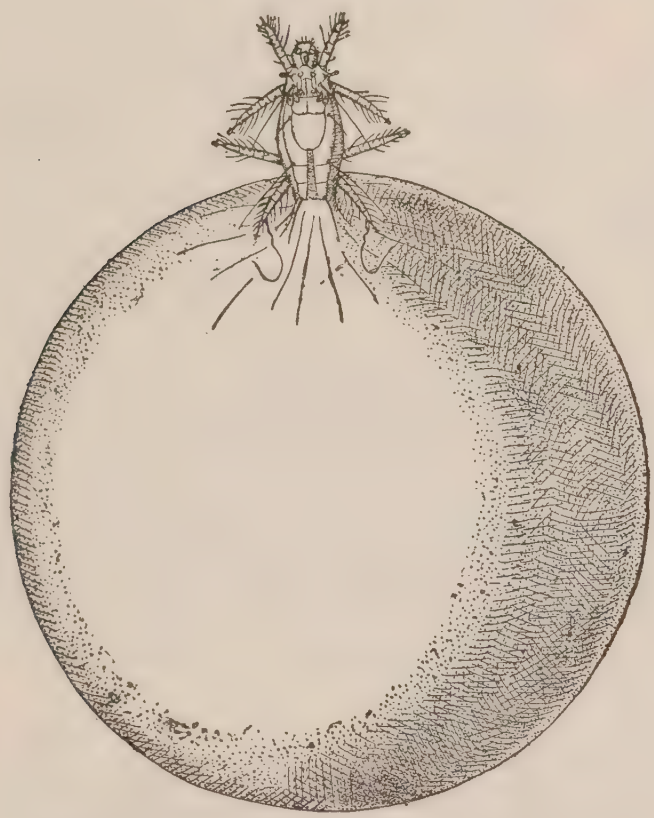


FIG. 216.—*Pediculoides ventricosus:* Gravid female. (Adapted from Brucker.)

FIG. 217.—*Siteroptes carnea* and claw. (Original.)

elevated the family into one of the principal groups (Heterostigmata) of the order. The dimorphism in certain forms seems to suggest affinity to the Tyroglyphidæ. The family was united to the Cheyletidæ by Trouessart, and some have foilowed him, but most later authors consider it distinct therefrom and more allied to the Tyroglyphidæ. Oudemans has elevated it into an order under the name Trachelostigmata, and a few other acarologists follow him. In any location it is an isolated group. The family can be divided into two subfamilies, as follows:

1. Hind legs of female end in claw and sucker, in male hind legs shorter than third pair..... PEDICULOIDINÆ.
   Hind legs of female end in long hairs, in male hind legs about as long as third pair..... TARSONEMINÆ.

In the Pediculoidinæ are two very distinct genera; others have been made by subdividing *Pediculoides*.

1. Mouth parts terminal and distinct..... *Pediculoides*.
   Mouth parts hidden by a cephalic process..... *Pigmeophorus*.

In 1850 Newport gave the name *Heteropus ventricosus* (fig. 214) to a mite found on the larva of a wasp. Since then similar mites have been found on various insects, both alive and dead. The generic name was preoccupied, and was changed to *Pediculoides*[1] by Targioni-Tozzetti in 1875. The species has become of much economic importance, since it is frequently parasitic upon injurious insects. The abdomen of the pregnant female (fig. 216) swells to an enormous size, this being due to the development of the eggs. These not only hatch within the parent, but obtain their entire development there, and issue as sexually mature males and females. These may wander about for a time on the body of the mother and soon pair. The body of the male (fig. 215) ends in a broad sucker, wherein is situated the penis. The tip of the female is grasped by this sucker. *P. ventricosus* Newp. occurs commonly in this country, and another species has been found on the larvæ of scolytid beetles. Prof. Herrera, the Mexican entomologist, endeavored without success to breed a Mexican species to kill the grubs of the cotton-boll weevil. Some species with a more distinctly segmented body and with short legs have been placed by Reuter in a new genus—*Pediculopsis*. One species, *P. dianthophilus* Wolcott, is a serious pest to carnations, and the principal agent in the distribution of the "bud-rot" of these plants. The mites burrow down inside the buds to feed on the tender tissues within and, going from bud to bud, carry the spores of a fungus which produces the rot. In this species the gravid female is egg shaped and not spherical. It is closely related and possibly identical with the *P. graminum* Reuter of northern Europe, which occurs on grasses and is said to be one of the causes of "silver top." Some species of *Pediculoides* commonly attack the injurious insects of grain, as the grain moth, *Isosoma*, *Meromyza*, etc. Thus it happens that if grain infested with these insects, upon which there are numerous *Pediculoides*, is used while fresh for straw, the mites, finding their natural food drying up, must leave the insects and hunt for other food. If this fresh straw is used, as is often the case, for mattresses, the mites crawling through the ticking, attack the sleeping person, and cause innumerable pustules whose intolerable itching induces scratching and consequent sores. This dermatitis was for many years a puzzle to physicians, but was connected with the mite by Dr. Goldberger, and Prof. Webster[2] has brought together a considerable number of cases where *Pediculoides* has been troublesome. So minute are these mites that they are practically invisible, and the disease caused by them was sometimes attributed to the injurious insects of the grain.

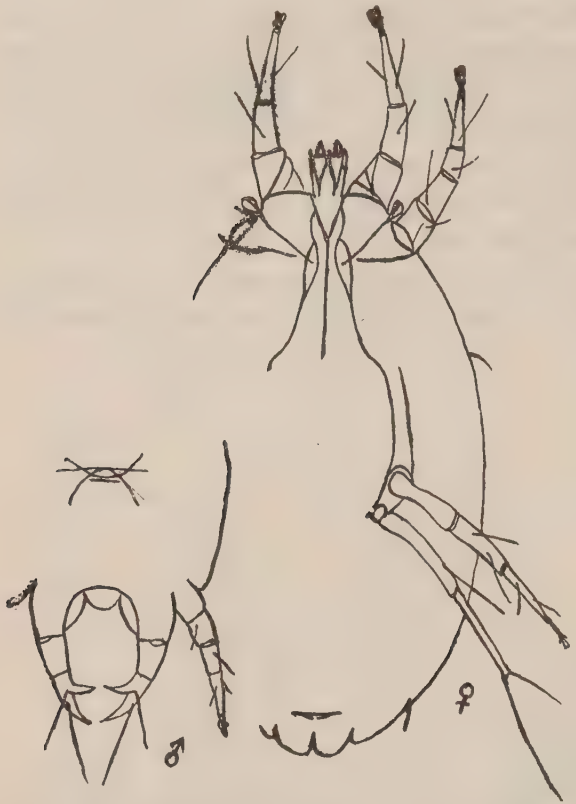


FIG. 218.—*Tarsonemus pallidus*. (Author's illustration.)

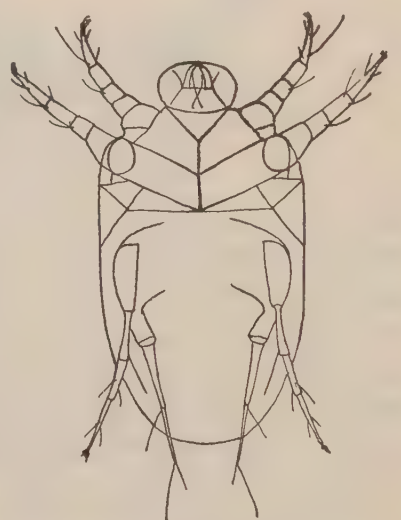


FIG. 219.—*Tarsonemus latus:* Female. (Author's illustration.)

[1] *Laïs* Filippi, 1865, is older, but this name is fortunately preoccupied by Hagen in 1853.

[2] Webster, F. M. A Predaceous Mite Proves Noxious to Man. (*Pediculoides ventricosus* Newport.) U. S. Dept. Agr., Bur. Ent., Circ. 118, 24 p., 13 fig., Apr. 23, 1910.

In various parts of Europe similar species of mites have caused similar dermatitis. Laborers carrying sacks of grain or working in the fields were attacked by mites, causing an eruption somewhat like nettle rash; this was called "grain fever" by the peasantry. In Hungary Geber records a mite, which he called *Chrithoptes monunguiculosus*, attacking men handling barley and causing an irritating inflammation of the skin so severe as to force the men to leave their work. Kramer also observed the mite under the same conditions. In France Lagreze and Robin have recorded similar

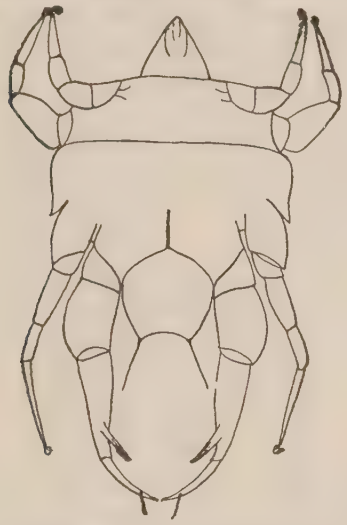


FIG. 220.—*Tarsonemus latus:* Male. (Author's illustration.)

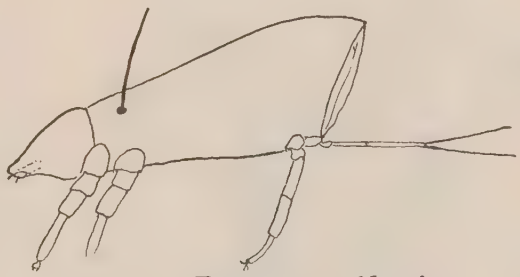


FIG. 221.—*Tarsonemus*, side view. (Original.)

cases, attributing the disease to *Pediculoides tritici* Lagreze. Various other cases are known from Roumania and Russia, so that this mite probably causes trouble in all grain-growing regions, and can only be eliminated by destroying the insects that commonly infest grain. In our country these cases have been confined to the Eastern States. If the wheat is thrashed immediately after harvest and directly from the field, the injurious insects will be largely destroyed, and there will be no damage from *Pediculoides;* however, it is not advisable to use fresh straw for mattresses.

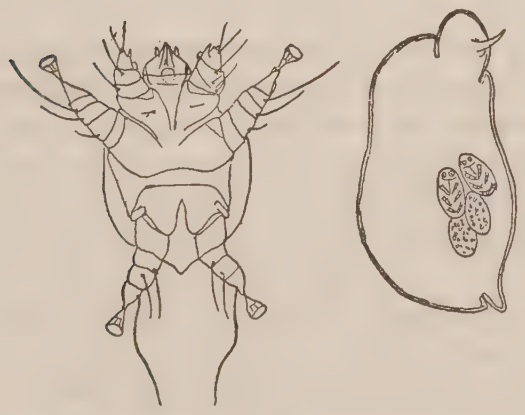


FIG. 222.—*Podapolipus*, male venter; female, replete, side view. (Original.)

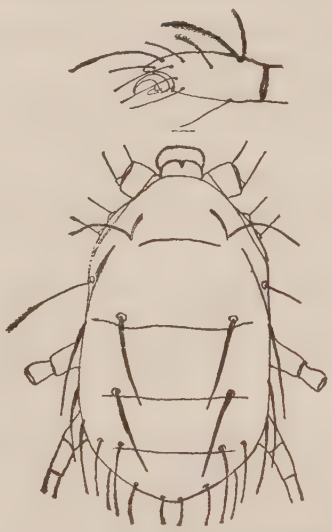


FIG. 223.—*Pigmeophorus americanus*, from above, and tarsus enlarged. (Author's illustration.)

Several other species have been assigned to this genus which feed on grain and grasses. One would suspect that they would fall in a separate genus, for which the name *Siteroptes* Amerling is available. One is *P. tritici* Lagreze, found in wheat heads; another is *S. carnea* Banks (fig. 217), abundant in deformed heads of some wild grasses in Colorado and New Mexico, where it produces a "silver top."

Pigmeophorus (figs. 223, 224) is closely allied to *Pediculoides*. It has a migratorial form, which in one case was found on a mole and in another on a fly. We have ob-

served a species in this country attached in some numbers to a fly, *Platycnemis imperfecta*. Other species have been found on the wings of the house fly, and attached to thrips, apparently in migration. The singular genus *Podapolipus* (fig. 222) of Rovelli

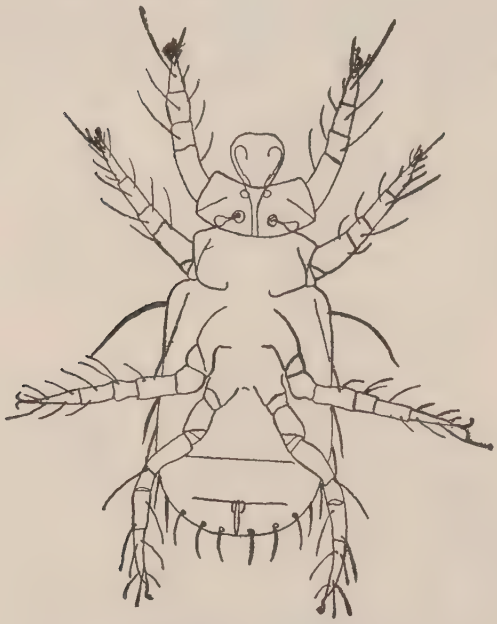


FIG. 224.—*Pigmeophorus americanus*, from below. (Author's illustration.)

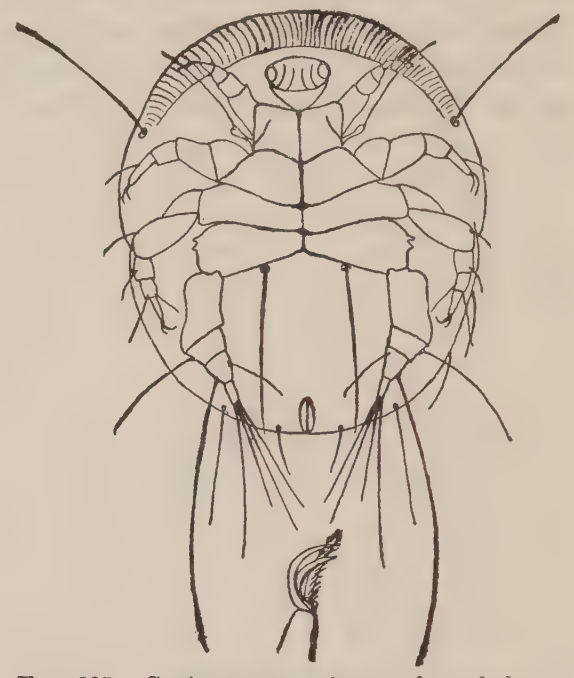


FIG. 225.—*Scutacarus americanus*, from below, and claw. (Author's illustration.)

and Grassi has but three pairs of legs; the female on hatching is similar to the male figured (fig. 222), but has a long bristle at the tip of the body. After pairing she molts, becomes tumid, and loses her legs, but retains a pair of clawlike processes in front by which she holds to the host insect. They occur under the elytra of tenebrionid beetles in South Europe and Africa. Trägardh redescribed the genus under the name of *Pimelobia*.

In the Tarsoneminæ there are also two very distinct genera:

1. Body broad, nearly circular, hiding the mouth parts and greater part of legs.....*Scutacarus*.
   Body elongate, mouth parts terminal; hind legs in male thickened, in female with two terminal hairs.....*Tarsonemus*.

The species of *Tarsonemus* (fig. 221) affect various plants, sometimes producing galls upon them. They live in colonies upon the leaf or stem at the base of flowers, or in the culms of grasses. One species, *T. oryzæ* Canestrini, infests rice in Italy; another, *T. culmicola* Reuter, produces "silver top" in certain grasses of Finland; a similar form produces the same appearance in some grasses of New Mexico. One grass stem may contain several million mites. Another species (*T. pellucens* Green) does considerable damage to tea in Ceylon. Tryon has described a species, *T. anasae* Tryon, as injuring pineapples in Australia. I have described one, *T. latus* Banks (figs. 219, 220), which causes galls on the main shoots of mango plants. Another species, *T. pallidus* Banks (fig. 218), has been found on various greenhouse plants in this country and sometimes causes great damage to the flowers. Michael has recorded a species, *T. bancrofti* Michael, as the cause of serious damage to sugar cane in Queensland. *T. canestrinii* Marchal produces small, rounded galls on several European grasses; *T. spirifex* Marchal forms elongate swellings on oats. *T. spinipes* Hirst injures sugar cane in the West Indies, attacking the stem and giving entrance to injurious fungi. *T.*

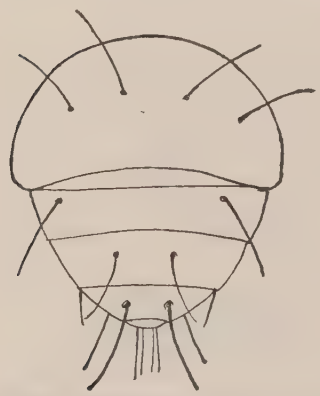


FIG. 226.—*Imparipes sp.* (Original.)

waitei Banks attacks the growing terminal twigs of peach trees and turns them into elongate, blackened, and distorted galls with many small lateral twigs and leaves growing from them. But few remedies have been proposed for these mites. A mixture of powdered sulphur in soap and water has been suggested for one on sugar cane. Picking infested parts has also been recommended.

The genus *Tarsolarkus* Thor is very similar to *Tarsonemus*, but has a pulvillus between the tarsal claws, and the body is slender and clothed with bristles; it occurs in moss in northern Europe. The curious genus *Scutacarus* (fig. 225) has a migratorial nymphal stage much like the hypopus of the Tyroglyphidæ. This stage has been found on bees and ants. The adult occurs on plants and among dead leaves. American species have been taken from bees of the genus *Apis*, *Halictus*, and *Nomia* Berlese describes several species from ants. He has divided the genus into three genera, as follows:

1. Leg I without claw.....*Diversipes.*
   Leg I with a claw..... 2
2. Leg IV without terminal caroncle.
   .....*Scutacarus.*
   Leg IV with terminal caroncle..
   .....*Imparipes.*

Most of the few known species remain in *Scutacarus*. This genus was first described by Gros in 1845, and renamed *Disparipes* by Michael, who did not know of Gros's paper. The species of *Imparipes* (fig. 226) have little resemblance to ordinary mites.

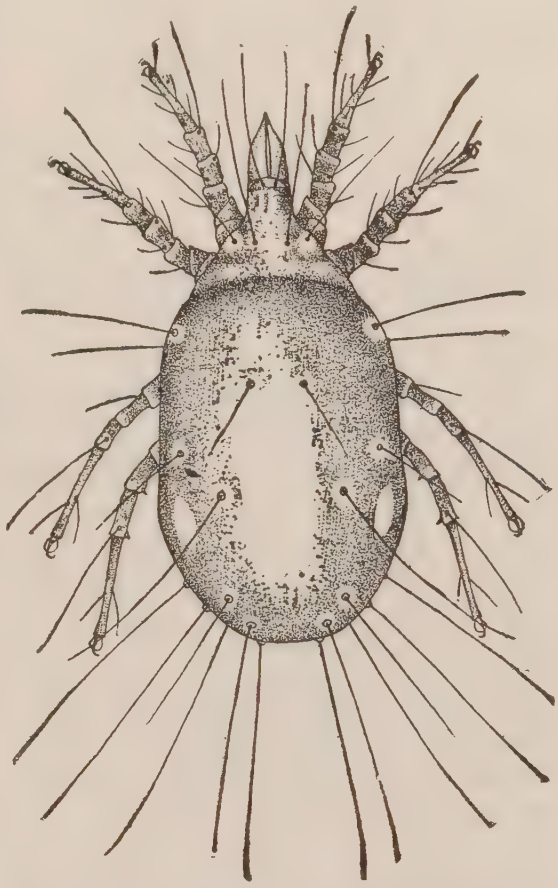


FIG. 227.—*Tyroglyphus* sp. (From Marlatt.)

FAMILY TYROGLYPHIDÆ.

The Tyroglyphidæ ("Sarcoptides détricoles" of Mégnin) is not a large family of mites, but many of them are of considerable economic importance, since several affect stored foods and the roots and bulbs of living plants. They have been known to naturalists from the time of Linnæus. In the adult condition they are usually free, but during one stage of their life, known as the hypopial, they are attached to various insects and sometimes small mammals. This hypopial stage, or hypopus, is a migratorial condition; the mite during this period takes no food, so it is not a true parasite. However, in some cases where they occur in enormous numbers they may injure the insect, owing to their weight or position.

The Tyroglyphidæ (fig. 227) are pale-colored, soft-bodied mites, devoid of tracheæ, usually with prominent chelate mandibles, small palpi, and moderately long legs ending in one claw and often a sucker. The body is about twice as long as broad, and broadest behind the middle. There is commonly a distinction between the cephalothorax and abdomen. There are no eyes (unless certain organs in a few hypopi and in *Carpoglyphus* are eyes). The dorsum bears a few, mostly long, hairs, and the legs have scattered hairs. One hair near the end of the penultimate joint of legs I and II is very long, and there is usually a clavate hair near the base of the tarsi of legs I and II, which may be a sense organ. It is always in this position, although authors sometimes figure it as arising from the preceding joint. On the venter are two apertures; the genital is usually elongate, and situate between the hind coxæ, and there are often two U-shaped marks each side of it, known as the genital suckers. The anal opening is

usually much before the tip of the body; it is often but an elongate slit, with a sucking-disk each side. In *Glyciphagus* the openings are much larger, and the genital sometimes occupies the entire area between the coxæ.

FIG. 228.—Hypopus of a *Tyroglyphus*, from below. (Author's illustration.)

The internal anatomy of the Tyroglyphidæ has been carefully studied by Nalepa and Michael. The digestive system is of the usual type; the ventriculus is very large, with two short cœca, the colon is globose, the rectum very large and open close to tip of body. Behind the anus is a small opening—the copulative aperture. In *Glyciphagus* the bursa copulatrix projects externally in a small cone. So in the Tyroglyphidæ as in the Analgesidæ, copulation is not performed through the vulva, but by this special opening. This opening leads to a receptaculum seminis, which connects by a small duct to the ovaries. The nervous system is chiefly concentrated in the very large "brain" which surrounds the œsophagus. The most powerful muscles of the mite are those attached to the mandibles, the legs, and the stomach.

As a rule there is little difference in size between the sexes, but Michael has described one form with the male not half as large as the female. In several cases there are well-marked secondary sexual characters, such as the enlargement of the first or third pair of legs in the male. In some species the male has two little suckers on the hind tarsi; in others there is a curved plumose bristle on the basal part of the front legs. The transformations of the Tyroglyphidæ are among the most marvelous of the animal kingdom. All Tyroglyphidæ (except *Carpoglyphus*) appear to lay eggs, which are scattered haphazard over the infested material. The young on hatching have six legs, and, molting, obtain two more. Thenceforward their life-history may take the simple and direct path to the adult condition, but often it passe sthrough what is called a "hypopus." This hypopus (fig. 228) is very different from the creature from which it has developed—the octopod nymph. Its body is hard and chitinous; there is no mouth-orifice and no distinct mouth parts. The legs are short and ill-adapted to walking. On the ventral surface of the body near the tip is an area distinct from the general surface and provided with several circular marks or sucking disks. By means of these sucking disks the Hypopus attaches itself to an insect or other creature and is transported to some other locality, where it may find a suitable breeding place. The Hypopus is thus a stage in the life of *Tyroglyphus* for the purpose of migration. The Hypopus, on finding a suitable locality, molts into an octopod nymph, which will feed and develop into an adult mite. The causes that will induce a nymph to transform to a Hypopus are not known. Mégnin supposed that the dryness of the air or

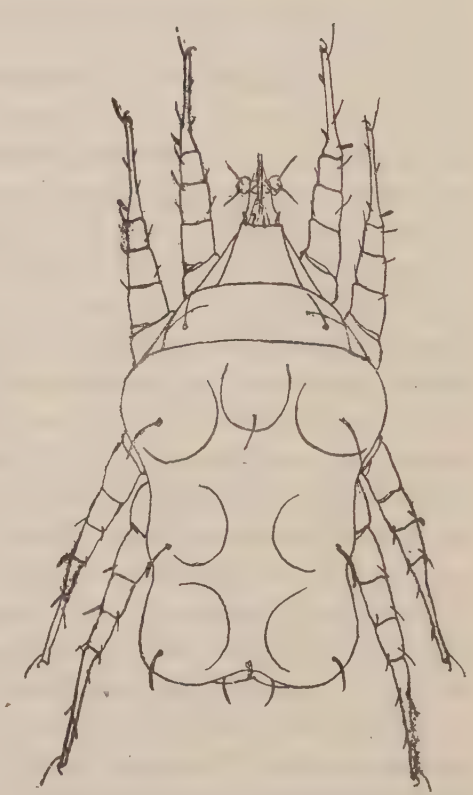


FIG. 229.—*Histiostoma americana*. (Author's illustration.)

the scarcity of food were necessary causes. But Michael has shown that hopopi are developed in the absence of these conditions, and that the hypopus is the natural and normal means of distributing the species. There are two types of hypopus: most of them are provided with a plate of sucking disks fitting them to cling to the smooth surface of an insect. A few, however, called the "homopus" type, do not have the

FIG. 230.—Beak of *Histiostoma americana*. (Author's illustration.)

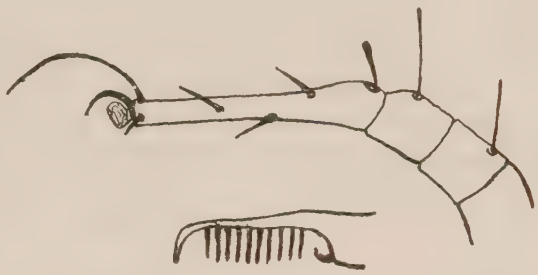


FIG. 231.—Leg I, and tip of mandible of *Histiostoma americana*. (Author's illustration.)

plate of sucking disks. They are fitted for clinging to the hairs of small mammals, and for this purpose there is a longitudinal groove on the ventral plate, and each side of the groove a broad, raised, striated surface that may be pressed against a hair lying in the groove. In the early days of acarology the relation of the hypopus was unknown, and *Hypopus* stood for a separate genus, allied more to *Gamasus* than to *Tyroglyphus*. The history of the discovery of its relationship is replete with interesting details. Dugès in 1834 wondered if *Hypopus* was not a larva. In 1844 Gervais placed *Hypopus* as a section or subgenus of *Tyroglyphus*, but not doubting they were mature creatures. Dujardin in 1847, after a close examination of the mite, decided that *Hypopus* was an immature migratorial form of *Gamasus*. In 1868 Claparede bred various tyroglyphids and noticed that certain nymphs when they transformed did not produce the adult *Tyroglyphus*, but a *Hypopus*. His observations were correct, but his conclusion that *Hypopus* was the male of *Tyroglyphus* was erroneous. About the same time Robin and Fumose published a paper in which they described the true male of *Tyroglyphus*, thus showing that *Hypopus* was not the male *Tyroglyphus*. In 1873 Mégnin published a famous work on the life history of *Tyroglyphus rostroserratus* Mégnin, in which he proved that *Hypopus* was a nymphal form of *Tyroglyphus*, due, he supposed, to the dryness of the atmosphere or the lack of food.

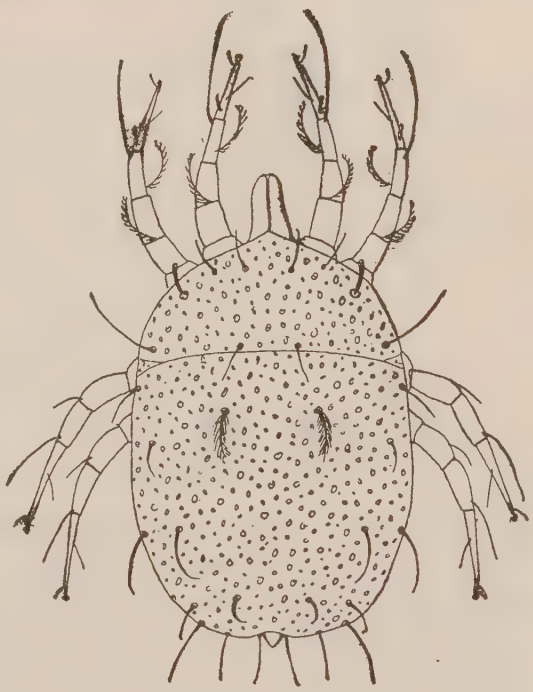


FIG. 232.—*Glyciphagus obesus*. (Author's illustration.)

Murray in 1876, in investigating the subject, came to the conclusion that *Hypopus* was a ferocious parasite which devoured the entire internal anatomy of its victim and then left the cast skin in search of fresh prey. Haller in 1880 accepted Mégnin's interpretation, in considering *Hypopus* the "traveling dress" of *Tyroglyphus*. In 1884 Michael went carefully over the whole ground, confirming the facts of Mégnin,

but holding that the hypopus was a natural stage in the development of most if not all tyroglyphi.

From an economic standpoint the Tyroglyphidæ are one of the most important groups of mites, but owing to their small size and pale color they have often been overlooked, and the damage accredited to some larger mite or insect that happened to be in the material. By their rapidity in breeding they make up for their minute size, so that foods, such as flour and sugar, are often so badly infested that the whole mass of the substance appears to be in motion. Dried fruits, dried meats, and grain in mills are, perhaps, most seriously affected by them. Their frequency in cheese and sugar has won them the names of "cheese mites" and "sugar mites," while the disease known as "grocer's itch" is due to their presence on the hands of persons handling infested products. A list of materials attacked by tyroglyphids would include cheese, flour, sugar, hams, dried meats, hair in furniture, mattresses and pillows,

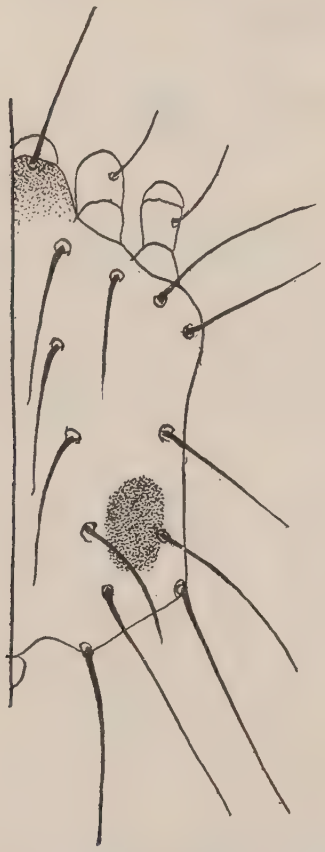


FIG. 233.—*Labidophorus sciurinus:* Male. (Original.)

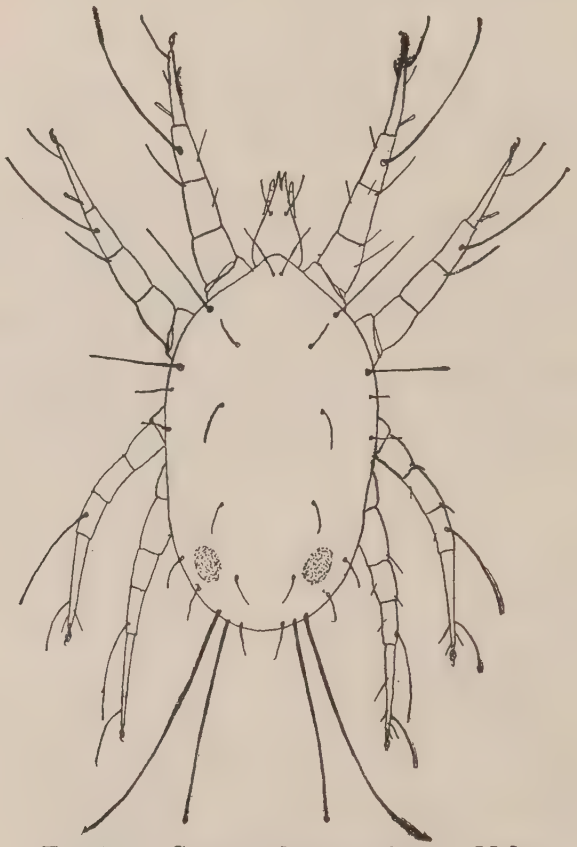


FIG. 234.—*Carpoglyphus passularum:* Male. (Author's illustration.)

grain in mills, cereal foods, many drugs, wine, dried fruits, jams and jellies, seeds of many kinds, bulbs, roots of plants, mushrooms, feathers, hay, refuse in nests, scale insects, pinned insects of the entomologist's collection, and even the human corpse.

Some species are, however, of little economic interest and occur in the nests of mice, moles, and ants, in decaying bark of trees, in sap from wounds in trees, and a few are attached to certain insects. The species of *Monieziella* do some good by feeding on scale insects. The "bulb mite" or "Eucharis mite," *Rhizoglyphus hyacinthi* Boisd., has long been a prominent enemy to hothouse cultivation. It burrows into the healthy tissue of bulbs and roots, thus giving entrance to destructive fungi and bacteria. This is the species infesting Bermuda lily bulbs, and it has been shown that an allied species does great damage to the roots of the vine in Europe. Another species causes injury to the stems of carnations. Still another *Rhizoglyphus* has been found to eat through the grafting wax on grafted plants, bore beneath the bark, and thus prevent the union of graft and stock. The mushroom mites, both in

this country and in Europe, are prominent obstacles to successful mushroom culture. Cellars apparently clean in the beginning of the season may be so badly infested by Christmas that crops are impossible.

It is a difficult problem to destroy tyroglyphids. Since they have no tracheæ, they are not very susceptible to fumigation, although some of them will succumb to prolonged treatment. Flowers of sulphur and carbolic acid are, at times, of much use; but in many cases destruction of the material attacked is the only remedy. Since many in the hypopial stage are carried by flies, it is advisable to have the windows screened in all factories where cereals, drugs, dried meats, and fruits are prepared. When very abundant the tyroglyphids are attacked by various predaceous mites, chiefly *Cheyletus* and *Parasitus*, which greatly reduce their numbers, and in some cases entirely destroy them.

Various species have at different times been recorded as temporarily parasitic on man, causing itching and soreness of skin. Persons handling infested products are apt to become attacked, but the mites soon disappear, as they can not breed on the skin.

Most of the Tyroglyphidæ differ but little in general appearance, and the characters that separate species are often few and minute. The family is usually considered to have affinity to the Sarcoptidæ and Analgesidæ, but there is more resemblance to the nymphs of the Oribatidæ; in fact, oribatid nymphs have been described as Tyroglyphidæ, and vice versa. The Tyroglyphidæ have always been kept as a separate group, either as a family, or as a subfamily of the Sarcoptidæ. Four groups, which may be considered subfamilies, have usually been recognized: *Glyciphagus* and its allies, *Histiostoma*, *Trichotarsus*, and the *Tyroglyphus* group. Most of the species belong to the last group. The principal genera may be recognized from the following table:

1. Mandibles not chelate, but elongate and toothed below; body without long hairs; palpi enlarged at tip, and provided with two divergent bristles.. *Histiostoma.*
   Mandibles chelate; palpi not enlarged at tip, not with the two bristles..... 2
2. Dorsal tegument more or less granular; claws very weak, almost invisible, some hairs of body plainly feathered; ventral apertures very large..*Glyciphagus.*
   Dorsal tegument not granular; claws distinct; no prominent feathered hairs; ventral apertures small..... 3
3. No clavate hair on base of tarsi I and II; no suture between cephalothorax and abdomen; no sucking genital disks; tarsi long..... 4
   A clavate or thickened hair on base of tarsi I and II..... 6
4. Body without bristles; tarsi without long apical hair, but one at tip of preceding joint; a medial frontal projection over mouth parts; genital opening large, penis slender, curved..... *Chortoglyphus.*
   Body with bristles, no long bristle at tip of penultimate joint of legs..... 5
5. Legs with spines; abdomen very bristly above..... *Hericia.*
   Legs without spines; living on bees or in their nests..... *Trichotarsus.*
6. The bristle on penultimate joint of legs arises from near the middle; no suture between cephalothorax and abdomen..... *Carpoglyphus.*
   The bristle on penultimate joint of legs arises from near the tip; a suture between cephalothorax and abdomen..... 7
7. Cephalothorax with four distinct and long bristles in a transverse row above; tarsi I and II about twice as long as the preceding joint..... *Tyroglyphus.*
   Cephalothorax with but two long, distinct bristles (besides the frontal pair), but sometimes a very minute intermediate pair; tarsi I and II often short..... 8
8. Tarsi with some stout spines; caroncle absent..... 9
   Tarsi without spines; caroncle present..... *Monieziella.*
9. Body very slender; the hind pairs of legs about their length behind the front pairs..... *Histiogaster.*
   Body robust; the hind pairs of legs but little beyond the front pairs..*Rhizoglyphus.*

The hypopi of the various genera, as far as known, can be separated by the following table:

1. A pair of clasping organs on venter near tip of body, margins not sharp-edged ..... *Labidophorus.*
   No clasping organs, but an area of suckers 2
2. Anterior legs end in very large claw; margins of body not sharp-edged .. *Trichotarsus.*
   Claws small or of normal size 3
3. An eyelike spot each side of anterior part of body ..... *Histiogaster.*
   No such eyelike spots 4
4. Venter behind with a submarginal crescentic plate; tarsi rather long ..... *Hericia.*
   No such crescentic plate 5
5. Legs very slender, especially the tarsi; hind legs often bent forward .. *Histiostoma.*
   Legs much shorter, the tarsi not slender 6
6. Five pairs of suckers in the plate arranged 2–2–4–2 ..... *Aleurobius.*
   Suckers not in such arrangement ..... *Rhizoglyphus* and *Tyroglyphus.*

FIG. 235.—*Aleurobius farinae:* *a*, Venter of male; *b*, leg I of male; *c*, palpus, *d*, tarsus IV of male. (Author's illustration.)

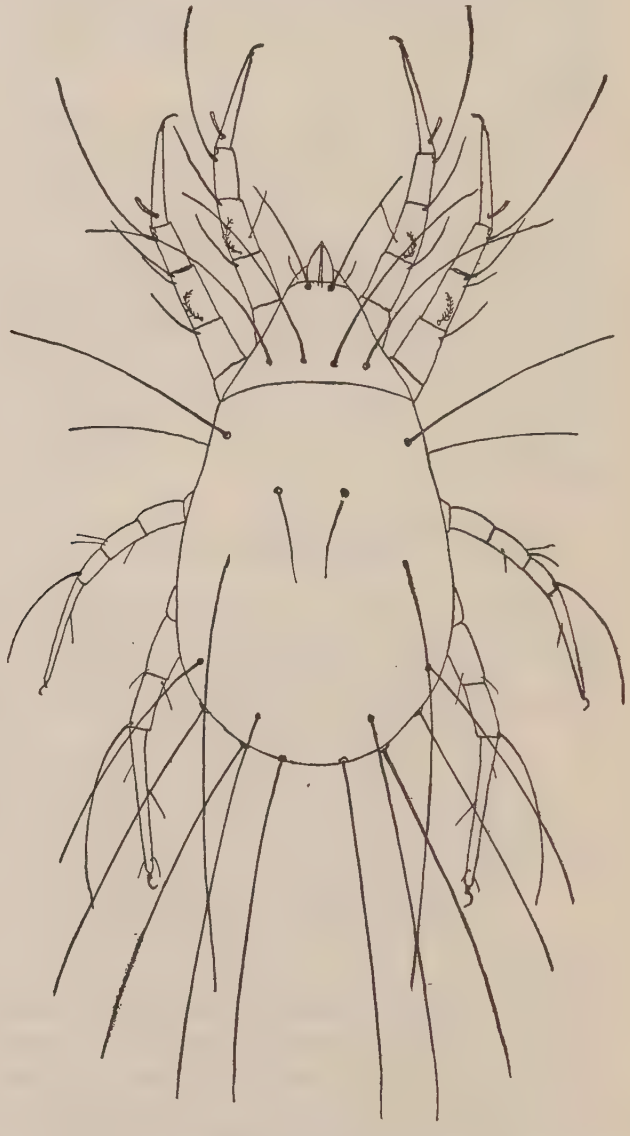


FIG. 236.—*Tyroglyphus lintneri:* Female. (Author's illustration.)

About five species of *Histiostoma* are known from the United States. They differ in length of legs and in shape of body. Some occur among dead leaves, others under bark with decaying matter. Their hypopi are often very abundant and have very slender legs. The hypopial stage of one (*H. muscarum* Koch) is often attached to house flies; another species, *H. americanum* Banks (figs. 229, 230, 231), was taken under bark, which was also infested with a *Rhizoglyphus*. This species has a number of humps on the dorsum of the body, and upon the summit of each is a small hair. In Europe one species lives in mushrooms and spreads a disease that causes the decay of the pileus. Nearly all the species occur in decaying material, but Jensen has

recorded that one species (*H. berghi* Jensen) lives parasitically in the egg capsule of a horse-leech in Denmark. From the egg hatches the six-legged larva, which soon molts into the nymph. The latter devours the embryonic leech and then passes into a hypopus. This escapes from the capsule, attaches itself to an insect, and, on reaching suitable locality, molts into a full-grown nymph. The latter cuts through the capsule, enters, and there transforms to the adult mite. Here reproduction takes place, and the life cycle begins anew. One species, *H. tarsalis* Banks, has been found in the nests of rats in California, and the hypopial form attached to the rat fleas.

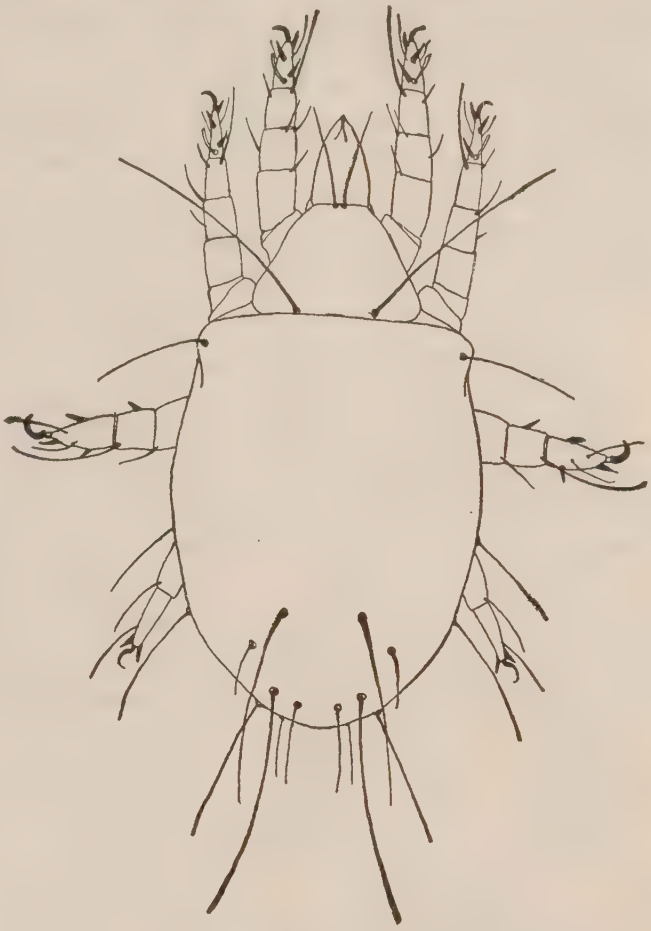


FIG. 237.—*Rhizoglyphus rhizophagus*. (Author's illustration.)

The genus *Glyciphagus* does not appear to be as common in this country as in Europe; possibly owing to their minute size they have not been collected. A few species, of rather modest appearance, are known to me. One (fig. 232) has long plumose hairs on the body, and was found in seeds. In Europe several species appear to be common in houses and other buildings. Some species are provided with many broad scalelike hairs. In all the forms the skin is finely granulate, which character serves to distinguish it from all other tyroglyphids. The original species of the genus (as indicated by the name) and some others have been found in sugar. The mites sometimes spread to the hands of those handling such materials, and produce a skin disease known as "grocer's itch." Michael has described two remarkable forms which he discovered in the nest of the mole. The body is broad, flat, and the margins crenulate and provided with spines. They do not occur in deserted nests, but their relation to the mole is unknown. They may, perhaps, form a distinct genus.

FIG. 238.—*Rhizoglyphus hyacinthi*, side view. (Original.)

The curious genus *Labidophorus* (fig. 233) has not been found in this country. The genus was based on a hypopus that is found attached to moles. Michael has worked out its life history, finding that the adult is much like *Glyciphagus*. The male has several curious comblike projections from the under side of the first and second pairs of legs and some plumose bristles on the other legs. The adult lives in the nests of moles. Another species occurs in the nests of squirrels and also on the squirrel. *Chortoglyphus* is known from but one species in this country, *C. gracilipes* Banks, which was found in tobacco infested by the cigarette beetle. The European species has been taken from old hay.

Tyroglyphus, the typical genus, is known in this country by 9 or 10 species, 3 of which are very common. One, a species in grain and stored foods, is *T. americanus* Banks. Another common species is the mushroom mite, *T. lintneri* Osborn (fig. 236), which is very close to the European *T. longior* Gervais, but having the bristles smooth. This species at times is very destructive to cultivated mushrooms, and once in a bed it is very difficult to eradicate it. Busck has given an account of experiments against it which serve to show the difficulty of dealing with the pest. Severely infested beds should be destroyed, and perhaps if the earth was steam heated (as is done for root-worms) the eggs would be killed. *T. longior* has the long hairs of the body distinctly plumose; it has been found in great abundance in barns and mills in Canada and the Northern States. Two species, *T. breviceps* Banks and *T. armipes* Banks, have been taken from the dead larvæ of insects, and several species have been found in ant nests. Dr. Felt has described a species, *T. heteromorphus* Felt, which caused injuries to the stems of carnations grown in greenhouses, and the same species occurs in other decaying vegetable matter. The third pair of legs are enlarged in the male.

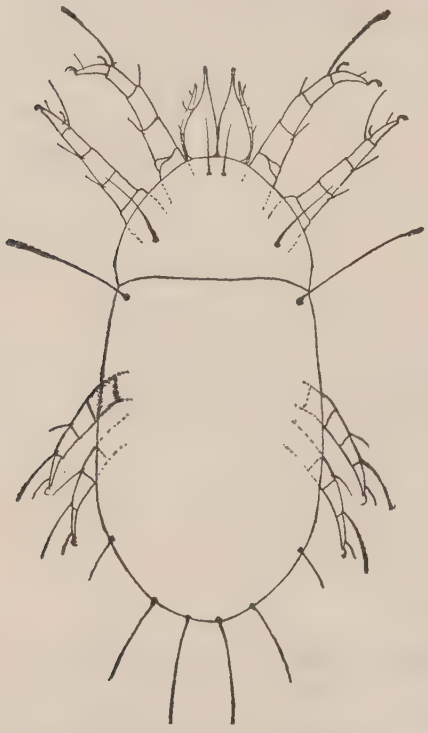


FIG. 239.—*Monieziella* sp.: Female. (Author's illustration.)

The genus *Aleurobius* has been used for a species of *Tyroglyphus*, *T. farinæ* De Geer (fig. 235), the male of which has enlarged front legs. This species appears to be well-nigh cosmopolitan and is most commonly found in flour, grain, and stored foods. The great enlargement of the anterior legs of the male is a unique character in the family. The body has a few rather short hairs. Cleanliness, window screens, and frequent handling of the grain will be the best preventives for the protection of mills against this pest. Fumigation with hydrocyanic-acid gas is the best remedy, but it may be necessary to repeat the treatment several times, as it is a difficult matter to destroy these mites.

The genus *Monieziella* (figs. 239–241) contains species that are predaceous on scale insects. Three species are known from this country, two on *Aspidiotus* and one on *Mytilaspis* scales. It is not certain whether they feed on the living scale insects or only upon the dead ones, but it is probable that they do both. They are fairly common and undoubtedly do much good in checking the increase of these pests.

To the genus *Rhizoglyphus* belong a number of species, found on the ground, in decaying matter, on roots of plants, and in bulbs. The body is slightly more pyriform than in most tyroglyphids, and the species are of rather large size. We have several species in the United States. One of them is the *R. hyacinthi* Boisduval (fig. 238) (*R. echinopus* Fumouze and Robin). This is the "bulb mite" or "Eucharis mite" of the horticulturists and is responsible for an enormous amount of damage. It burrows into healthy tissue, thereby giving entrance to destructive fungi and bacteria. It is especially common in hothouses, where its ravages on orchids have long been known. No one appears to have found a successful treatment. The best way is to burn the affected bulbs as soon as discovered. Some growers, however, secure good results by the following treatment: The soil of the pots of infested plants is allowed to become dry; then the bulbs are taken out and washed in a solution of tobacco water and soft soap, with a small amount of washing soda. Then they are sprinkled with freshly slaked lime and left for two days. Then they are washed with the same solution as before, to which a little petroleum has been added. They are then repotted and often do well. Mr. Woods has shown that this mite, when infesting Bermuda lilies, can not be destroyed, but much good is accomplished by the use of commercial fertilizers and rotation of crops. *R. rhizophagus* Banks (fig. 237) is a similar form.

In Europe it has lately been proved that this or an allied species does great damage to the roots of grapevines, and that it may be destroyed by the use of carbon bisulphid injected into the soil above the infested roots. Another species has been found to eat through the grafting wax on budded plants, bore beneath the bark, and so prevent the union of graft and stock. A species described by Riley, *R. phylloxerae*, was supposed to feed on the *Phylloxera*, but it doubtless fed on the grape roots and is common on decaying roots and tubers in the Eastern States. It may aid in the distribution of disease.

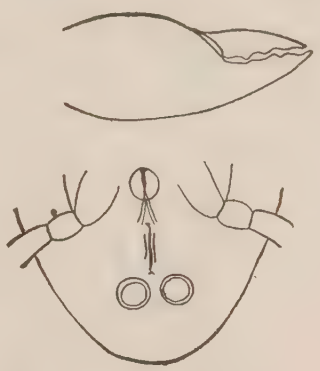


FIG. 240.—*Monieziella* sp.: Mandible and venter. (Author's illustration.)

The typical species of *Carpoglyphus*, *C. passularum* Hering (fig. 234), has been found on dried figs in California and elsewhere, on dried apples, smoked ham, and on pollen of honeybees. It infests dried fruit in Europe. In this genus there is no furrow separating the cephalothorax and abdomen. The position of the long hair on the tibia of legs I and II is different from that of any other tyroglyphid. This hair is normally near the tip of the tibia, but in this genus it arises from near the middle of the joint. There are only short hairs on the dorsum of the body, but at the tip are two long hairs each side. It is claimed that the female is ovoviviparous.

One species of *Histiogaster* (fig. 242) is known from Arizona, where it burrows in the decaying stems of alfalfa; a similar species in Europe burrows in the stems of reeds It is not certain whether they attack healthy tissue, but from the near

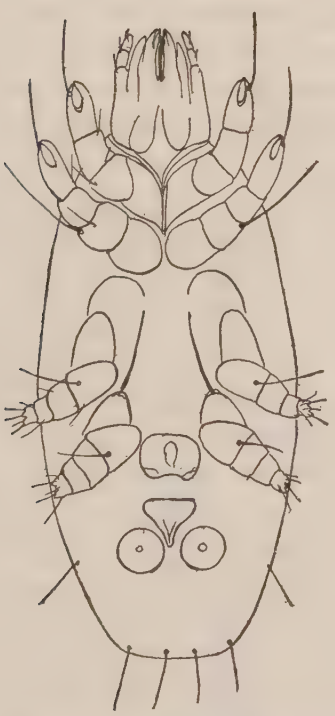


FIG. 241.—*Monieziella* sp., from San Jose scale. (Original.)

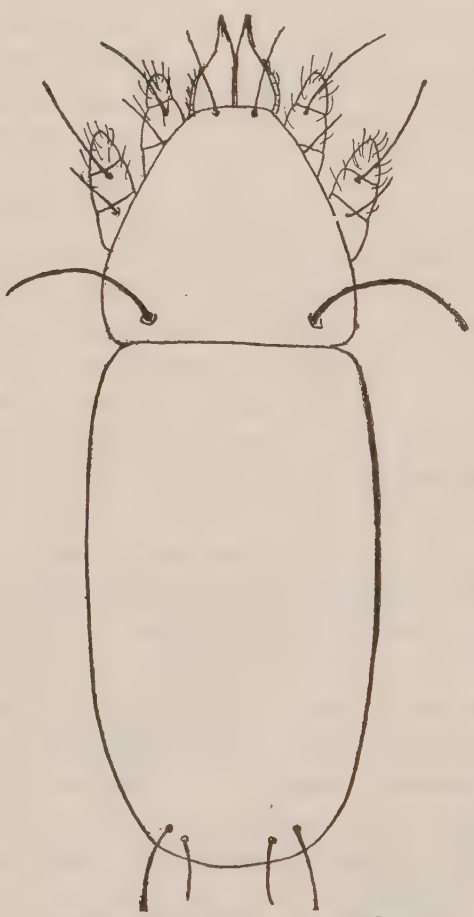


FIG. 242.—*Histiogaster xylophaga* (Original.)

relation of the genus to *Rhizoglyphus* it is probable that they do so, and thus give entrance to destructive fungi. The hypopus of *Histiogaster* has a glassy eyelike spot on each anterior side of the body; there is no evidence that it is an organ of vision. The species of the genus *Trichotarsus* (formerly *Trichodactylus*) are peculiar in that they occur in hypopial form on bees. They have a broad body, without division into cephalothorax and abdomen, and provided with a few short hairs.

Two species, *T. xylocopae* Donn. (fig. 243) and *T. osmiae* Dufour, are common in Europe and both have been recorded from this country. The adult of one species was found in the bee's nest and has much the appearance of the ordinary *Tyroglyphus*.

FIG. 243.—*Trichotarsus xylocopae:* Nymph, and claw enlarged. (Author's illustration.)

Some species of *Trichotarsus* occur in the basal abdominal cavity of certain old-world bees (*Koptorthosoma*) in association with the *Paragreenia* mites. They probably do not feed on the bees, and their relations to the *Paragreenia* are unknown. Oudemans has divided the genus into several on very slight characters.

The European genus *Hericia* is allied to *Trichotarsus* and is found in the sap flowing from wounds on trees. The European genus, *Fusacarus*, has a hard body and the mouth parts are not visible from above. It has been taken from moles' nests. The genus *Hyadesia* (*Lentungula*), found on marine algæ in England, Heligoland, and the Antarctic, is peculiar in having a slender hook-tipped process near the tips of tarsi I and II. A new genus and species has been recorded as injurious to the roots of the vine in Italy (*Heteroglyphus vitium* Foa), but it appears to be close to *Rhizoglyphus*, and probably is a synonym of it.

FAMILY CANESTRINIIDÆ.

This family, named in honor of the famous Italian acarologist, Giovanni Canestrini, comprises only a few forms of very small size and parasitic on insects. They are related to the Sarcoptidæ and also apparently to the Tyroglyphidæ. The body is entire, although there is usually an indication of the transverse furrow on the dorsum. The legs are rather short, with few hairs, and terminate in a sucker like that of the Listrophoridæ. The mouth parts are small and concealed in the rostrum; the mandibles generally chelate. The palpi are simple and filiform. There are sometimes two suckers on the hind part of the venter for copulatory purposes. The dorsum bears a few hairs or bristles and some longer ones at tip. Their life history has not been investigated. Most of the species occur on beetles, some under the elytra. One species that has been recorded from this country, *Hemisarcoptes coccisugus* Lignières (fig. 245), lives among the eggs of *Lepidosaphes ulmi* L. and other scale insects. It feeds on the eggs or on the scale and is thus very beneficial, but unfortunately not common enough materially to reduce the numbers of these insect pests. It was first described from Ohio as *Acarus malus* by Shimer and also occurs in Europe.

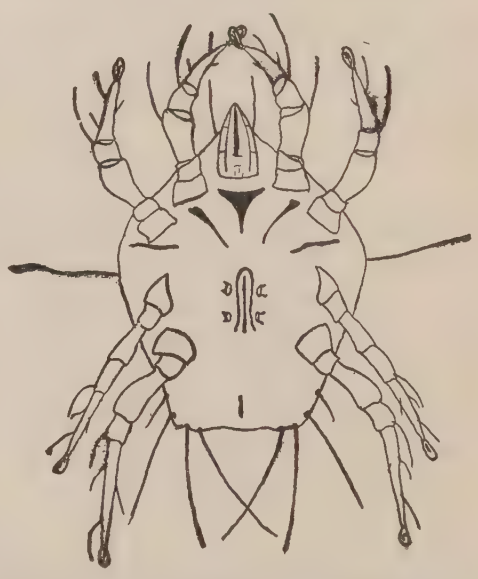


FIG. 244.—*Canestrinia* sp.: Female from below. (Author's illustration.)

The principal genus is *Canestrinia* (fig. 244), of which various species have been described in Europe and Africa. Several undescribed species occur on lamellicorn and other beetles in this country. A large form, *C. blattophaga*, occurs commonly on cockroaches in Central America. I have described a remarkable Mexican species

with a T-shaped process in front of the body as *Acrotocarus mirabilis* Banks. The principal genera may be distinguished as follows:

1. Tarsi very short, ending in a long-stalked clavate sucker..... *Hemisarcoptes.*
   Tarsi usually much longer than preceding joints, ending in a pointed or lobed sucker..... 2
2. Male with anal suckers; cephalothorax with long bristles; tarsal suckers cordate; mandibles chelate..... *Canestrinia.*
   Male without anal suckers..... 3
3. Tarsal suckers cordate; mandibles with only one toothed jaw; genital aperture behind coxæ IV..... *Linobia.*
   Tarsal suckers lobed; mandibles chelate; genital apertures between coxæ IV or in front of them..... *Coleopterophagus.*

Berlese has divided *Canestrinia* into four subgenera according to the family of the host-beetle.

Family ANALGESIDÆ.

The bird mites ("Sarcoptides plumicoles" of Mégnin) form one of the largest and best-known groups of the Acarina. Since the specimens can be found on the skins of birds, collections have been made in various museums, so that many species native to tropical countries are described—a condition not existing in other groups of mites, except the Ixodidæ. The species in the United States, however, have been but little studied. The body of an analgesid (fig. 246) is more or less elongate; the skin is soft and transversely wrinkled; in many forms there are finely granulated dorsal shields, one anterior and a longer posterior one; there are neither eyes nor stigmata; there is usually a distinction between cephalothorax and abdomen. In front there is a conical projection, the rostrum; the upper part of this is known as the epistoma, and is continuous with the dorsal surface of the body. Beneath the epistoma are a pair of triangular simple mandibles, which often project beyond it. The mandibles are commonly chelate, and finely toothed at the tip. Below the jaws are a pair cf maxillæ, which bear on their outer side the simple three-jointed palpi. Below this is the lower lip, and between the two is a ligula or tongue. The legs are commonly short and stout; they are arranged in two groups, the anterior pairs close to the mouth parts, the posterior pairs toward the end of the body. From their insertion on the venter there extend inward chitinous brown rodlike pieces, the epimera, which form a framework or skeleton for the attachment of muscles and support of the legs. The legs are of five joints, the last ending in a cup or saucer shaped sucker, caroncle (fig. 247), or ambulacrum, and sometimes with one or two claws. The legs bear a few hairs or bristles in a definite arrangement. The two hind pairs of legs often differ in the sexes, and in the male one leg is often enlarged or longer than the other and used as claspers. Sometimes there are projections or apophyses on the legs. In some forms there is a backward projection from some of the basal joints of leg I; these are the olecranon processes. On the dorsum are stiff bristles, the size and arrangement of which afford good specific characters. The vulva is situated between the bases of the third and fourth pairs of coxæ; it is usually marked by a curved line, which is termed the lyra.

Fig. 245.—*Hemisarcoptes malus:* Female. (Original.)

In the male there is a smaller U-shaped mark. The copulatory opening of the female is, however, a small aperture behind the anus. The anal aperture is a simple slit at the tip of the body. Each side of it in the male there is a circular mark or sucking disk; these are the mating or copulatory suckers. The tip of the abdomen is frequently of a different shape in the two sexes. In many genera the male abdomen is deeply bifid or bilobed at tip, while the female has the tip entire. In some forms it is more bifid in the female. In some cases the tip is provided with foliaceous plates or lamellæ. In a few genera there are two forms of the male; in one the mandibles and anterior legs are enlarged.

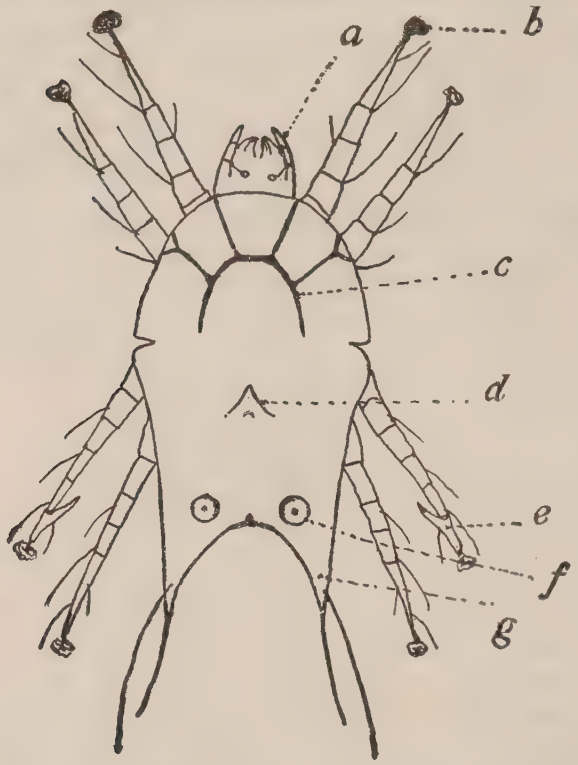


FIG. 246.—An analgesid: *a*, Palpus; *b*, caroncle *c*, epimera; *d*, genital opening; *e*, process; *f*, anal suckers; *g*, lobe. (Author's illustration.)

The development and life history of the bird mites are replete with remarkable facts—facts which have puzzled investigators for years, and even now not thoroughly understood. The egg is comparatively large, elongate, and slightly curved. The newly-hatched larvæ have six legs, but in some forms apparently but four. It has been claimed that it is the third pair of legs that is added when the larva transforms to the nymph. The nymph has the general form of the adult, but lacks the genital organs. In certain species there is a hypopial stage developed from the nymph. It is distinguished from the nymph by the absence of mouth parts, and by having long hairs, instead of a claw, at the tip of leg IV. This stage has on the venter an area of sucking disks similar to that of the hypopus of the Tyroglyphidæ. The adult male is developed from the nymph. But in the case of the female there is a passage form between the nymph and the true adult female. It has been called the nymphal or copulating female (femmina accoppiata), for it is in this stage that pairing occurs. The male mates with the nymphal female, but pairing is prolonged for several days or until the true adult is fully developed within this nymphal female. Pairing is performed through a small aperture behind the anus and not by the vulva, which latter is not developed in the nymphal female and only appears in the adult. The oviduct opens by the vulva. When the true female escapes from the nymphal female, an egg, already of considerable size, is seen within her body.

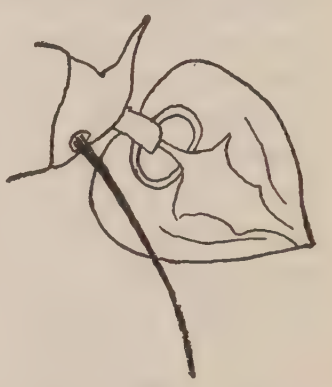


FIG. 247.—Caroncle of *Pterolichus*. (Author's illustration.)

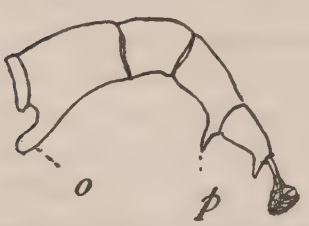


FIG. 248.—Leg of *Analges*: *o*, Olecranon process; *p*, tarsal process. (Author's illustration.)

The Analgesidæ live upon birds, feeding on the feathers, epidermal scales, etc. They rarely do any damage to the birds, but are usually of service in keeping the skin and feathers clean. They remain on the host after death, often leaving the feathers and congregating on the skin. Although many of the species are now known from but one host, there are some common forms that occur on a considerable number of birds, frequently of different genera. Likewise several species of mites sometimes occur on the same bird. One species is known to occur on birds belonging to five different families. However as a rule they do not spread

readily, and it has been noted that the species common on birds of prey are not like those found on the victims of these birds. Ewing has found that the mites will live for three days after removal from their host.

These mites were for a long time kept in the genus *Dermaleichus* Koch, but this has been shown to be a synonym of *Analges* Nitzsch, 1818. Many other genera have been formed in recent years, and a revision of the family by Canestrini, in "Das Tierreich," in 1899, includes 31 genera and 7 subgenera. Several, however, are based on very slight characters, and do not appear advisable.

But few species have been recorded from this country. Mr. Tyrrell and Prof. Haller described several from Canada, and Dr. Trouessart has taken some from Ameri-

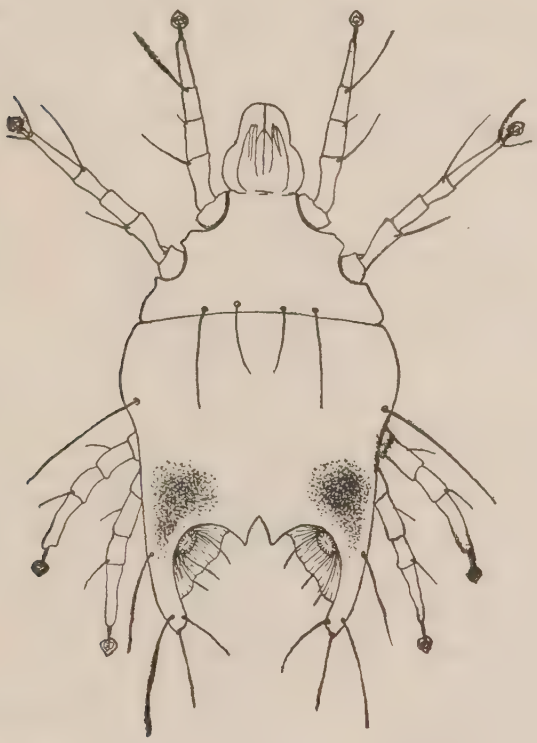


FIG. 249.—*Pterolichus* sp. (near *delibatus*), on condor. (Author's illustration.)

FIG. 250.—*Hypoderas columbae*, a stage of *Falculifer*: *a*, *b*, *c*, Epimera. (From Kellicott.)

can birds in the Paris museums. Various classifications have been made by different observers; Trouessart proposed a simple arrangement of genera in three groups, as follows:

Analgeseæ: Anterior legs with spines; females with tip of abdomen entire.
Genera: *Analges*, *Protalges*, *Analloptes*, *Xolalges*, *Megninia*.
Pterolicheæ: Anterior legs unarmed; females with tip of abdomen entire.
Genera: *Freyana*, *Pterolichus*, *Protolichus*, *Pseudalloptes*, *Xoloptes*, *Pteronyssus*.
Proctophyllodeæ: Anterior legs unarmed; females with tip of abdomen divided.
Genera: *Proctophyllodes*, *Pterodectes*, *Alloptes*, *Pterocolus*.

Oudemans has proposed a new arrangement of this group (which he calls Acaridæ) based on the presence or absence of vertical hairs on the cephalothorax. By using this with the characters previously known he makes 18 subfamilies. These vertical hairs are, no doubt, of value in classification, but can better be utilized to define genera rather than as a prime divisory character in a superfamily. In some species these erect hairs are short and minute, so that they are easily overlooked. Two genera have but one (a median) vertical hair.

In the table following I have included all known from the United States and Canada, and most of the larger genera that are apt to be found here.

1. No vertical bristles on cephalothorax 2
   A median vertical bristle on cephalothorax ..... *Eustathia.*
   Two vertical bristles on cephalothorax 8
2. Ambulacral caroncles flat, circular, almost sessile 3
   Ambulacral caroncles bell shaped, on short peduncles; male without genital disks 6
3. Abdomen of female not deeply cleft ..... *Avenzoaria.*
   Abdomen of female deeply cleft 4
4. Legs III and IV of male subequal in thickness 5
   Leg III thicker than IV; lobes of female abdomen long ..... *Allanalges.*
   Leg IV thicker than III; lobes of abdomen very short ..... *Alloptes.*
5. Abdomen of male entire behind; vulva simply arched ..... *Proctophyllodes.*
   Abdomen of male cleft behind; vulva more strongly curved, horseshoe-shaped ..... *Pterodectes.*
6. Legs, especially the hind pairs, much thicker in male than in female .. *Microlichus.*
   Legs not noticeably thicker in male 7
7. Peduncle of caroncle is placed at tip of tarsi ..... *Rivoltasia.*
   Peduncle of caroncle is placed before tip of tarsi ..... *Epidermocoptes.*
8. Legs I and II with a spine under one or two joints 9
   No spines on legs I and II 13
9. Leg III of male without caroncles, thicker than leg IV ..... *Analges.*
   Leg III of male with caroncles 10
10. Leg III of male thicker than IV, with spines on the tarsi ..... *Megninia.*
    Leg III not thicker than IV 11
11. Legs III and IV subequal in thickness, but III longer than IV ..... *Protalges.*
    Leg IV thicker and longer than III 12
12. Leg IV of male without caroncle ..... *Xolalges.*
    Leg IV of male with usual caroncle ..... *Analloptes.*
13. Hind legs of male not lengthened nor enlarged 14
    Some of the hind legs larger or longer than anterior legs 19
14. Legs III and IV short, placed more under the body nearer to the median line; front legs of male with processes on some of the joints; body usually rather short ..... *Freyana.*
    Legs III and IV more marginal; front legs without projections in the male .. 15
15. Legs I and II of male very much larger and longer than III ..... *Falculifer.*
    Legs I and II of male not particularly larger or longer than III 16
16. Leg III of male much thicker than IV 17
    Leg III not much if any thicker than IV ..... *Bdellorhynchus.*
17. Leg IV not noticeably larger than III 18
    Leg IV plainly larger than III ..... *Pseudalloptes.*
18. Epimera I in both sexes united to the sternum; genital disks usually approximate; tip of abdomen usually entire ..... *Thecarthra.*
    Epimera I not united to sternum; genital disks usually wide apart; tip of abdomen usually bifid ..... *Pterolichus.*
19. Leg III of male much thicker than IV 20
    Leg III of male not much thicker than IV 21
20. Abdomen of male more or less bilobed at tip; leg III usually reaches behind the abdomen, and has no teeth near base ..... *Pteronyssus.*
    Abdomen of male entire; leg III usually does not reach beyond end of abdomen, and has teeth on one of the basal joints ..... *Dermoglyphus.*
21. Leg IV without caroncle ..... *Xoloptes.*
    Leg IV with caroncle ..... *Syringobia.*

In *Freyana* some males have one of the first or second pairs of legs greatly enlarged and elongated for the purpose, it is supposed, of holding the female. Sometimes the enlarged leg is on the right side, sometimes on the left side, and to support it the sternal skeleton is much stronger and differently arranged from that on the opposite side of the body. This is the only instance of asymmetry in the family. The hind legs arise nearer the middle of the venter than in other genera, and are very short. Two species have been recorded from this country, one, *F. anserina* Koch, on the snow goose, and the other, *F. caput-medusae* Trouessart, on the booby. The latter species is sometimes over 1 mm. long, one of the largest species of the family. In *Pterodectes* (fig. 258) the body is elongate and slender, the legs all of about equal development, and in both sexes the tip of the abdomen is bilobed, in the female with two stout bristles. There are distinct shields upon the dorsum. Two species have been found in Canada on various song birds. The genus *Allanalges* (*Pterocolus*) is

scarcely different. Professor Haller recorded one species, *A. gracilepinnatus* Haller (fig. 257) from Canada.

In *Proctophyllodes* the body is also slightly elongate, and the legs of subequal size. The abdomen in the female is bifid at tip and with two stout bristles; in the male it is scarcely bifid and provided with two prominent foliaceous appendages. *P. reticulifer* Trouess. was taken on a California bird.

In *Rivoltasia* (fig. 259) the species are rather short and broad, and all legs of about equal size; the male body is deeply bilobed at tip, each lobe provided with a very long hair. They are very small species. Some occur on domestic fowls, and one is found on

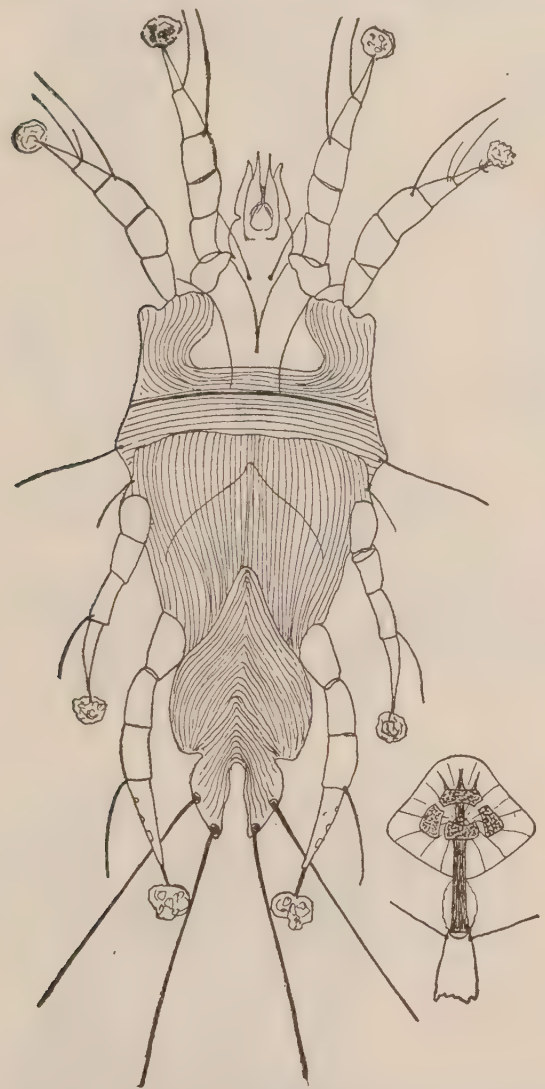


FIG. 251.—*Alloptes microphaethon* and caroncle. (Author's illustration.)

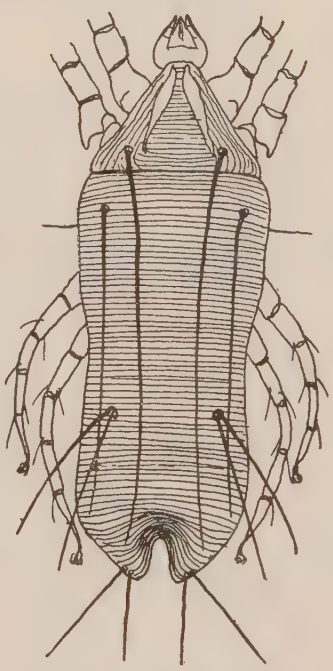


FIG. 252.—*Analges passerinus:* Female. (Author's illustration.)

pigeons. In *Microlichus* the species are similar to *Rivoltasia*, but the legs are shorter and end in distinct claws, and there are two hook-like projections each side of the rostrum near its tip. *Alloptes* (fig. 251) is similar to *Proctophyllodes*, and contains many species occurring on tropical birds.

In *Pterolichus* (fig. 249) the legs are all subequal in size. There is much variation in the shape of the body, which in the male is bilobed at tip and in the female more or less entire. It is a very large genus, and three species are known to occur in the United States. *P. aquilinus* Trouessart has been taken on the golden and bald eagles; *P. buchholzi* Canestrini on the godwit and golden plover; and *P. longiventer* Mégnin and Trouessart on the barred owl.

The genus *Falculifer* (formerly *Falciger*) has few species, but one of them, *F. rostratus* Buchholz, presents several interesting points. The adult stage differs but little from the normal bird mite, except that there are two forms of the male—one

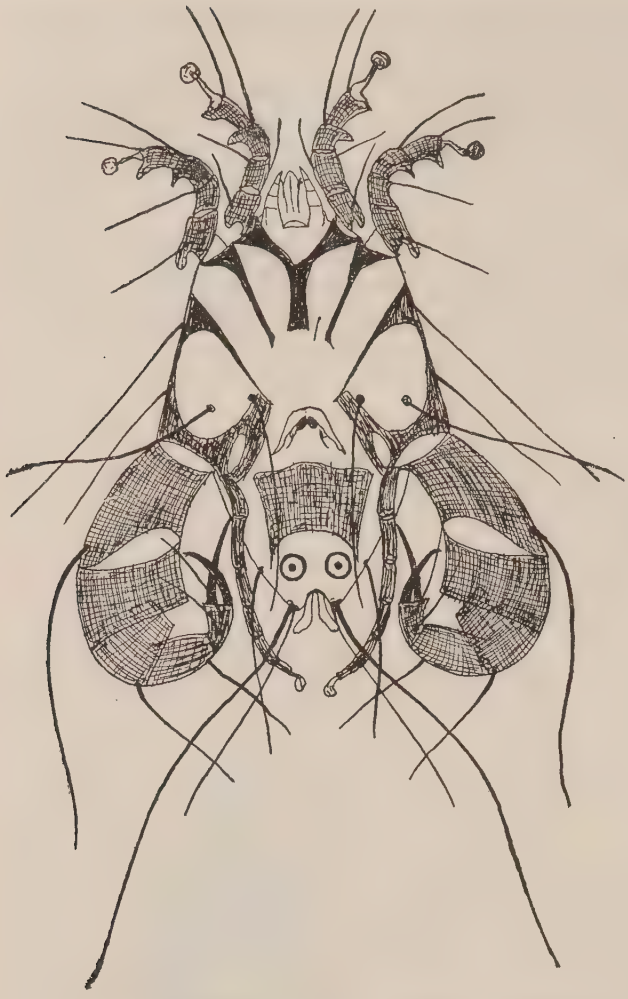


FIG. 253.—*Analges passerinus:* Male. (Author's illustration.)

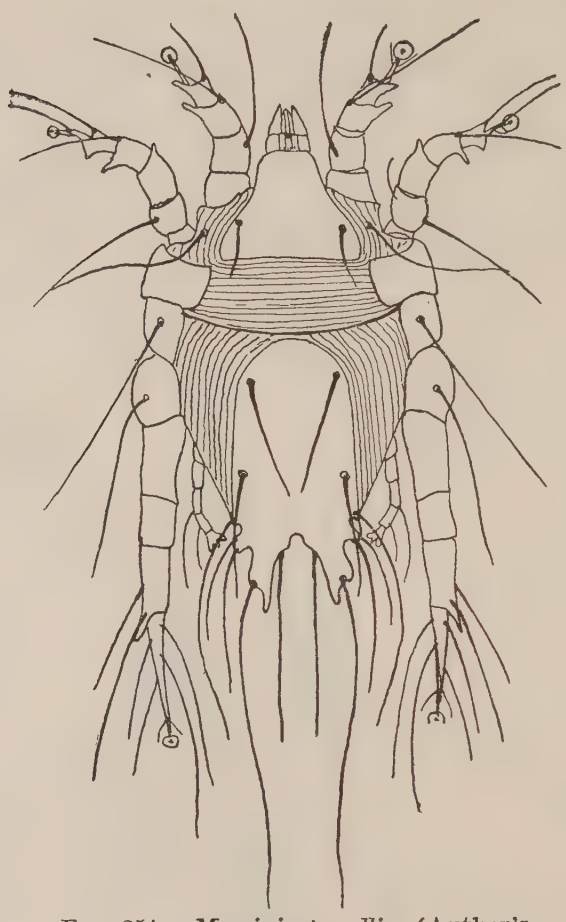


FIG. 254.—*Megninia tyrrelli.* (Author's illustration.)

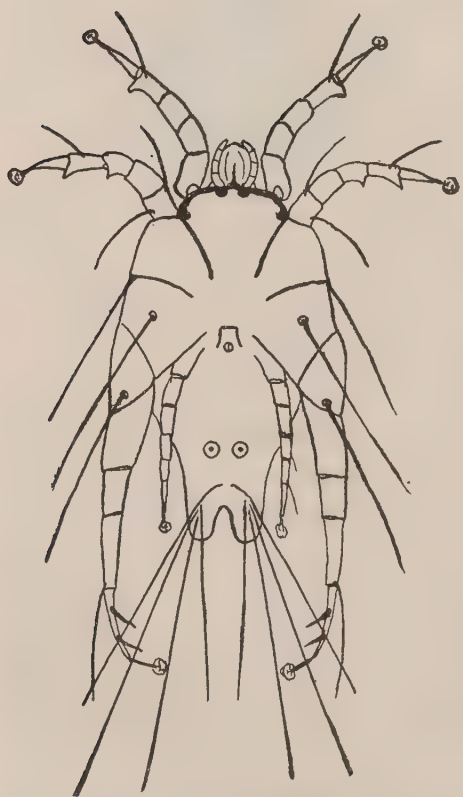


FIG. 255.—*Megninia albidus.* (After Tyrrell.)

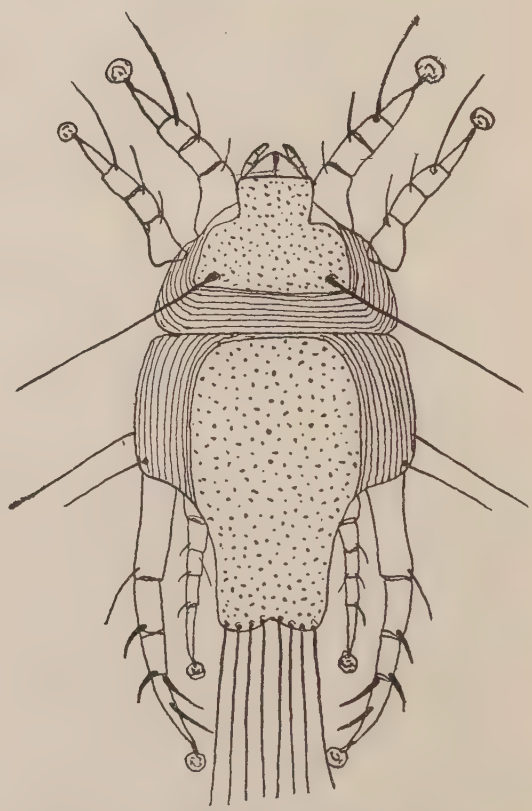


FIG. 256.—*Pteronyssus tyrrelli.* (After Haller.)

which has considerable resemblance to the female and the other which has several secondary sexual characters, the anterior pairs of legs being long and heavy and the immovable finger of the mandibles being greatly enlarged and lengthened. There is, however, an hypopial stage in the life of this mite which has been the theme of much discussion among acarologists for many years. This hypopial form was described in 1861 by Filippi as *Hypodectes* and by Nitzsch as *Hypoderas* (fig. 250). *Hypodectes* is found in various parts of the internal anatomy of birds, generally in the areolar and peritracheal tissues. It is of an elongate form, rounded in front and behind, and with eight short legs, two pairs in front and two other pairs toward the posterior end. There are no mouth organs, and Slosarsky, who examined the anat-

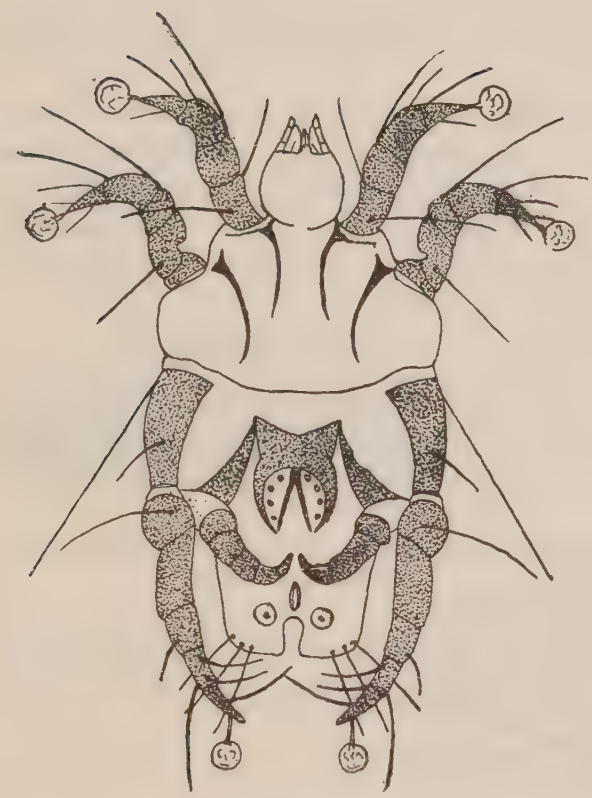


FIG. 257.—*Allanalges gracilepinnatus.* (Author's illustration.)

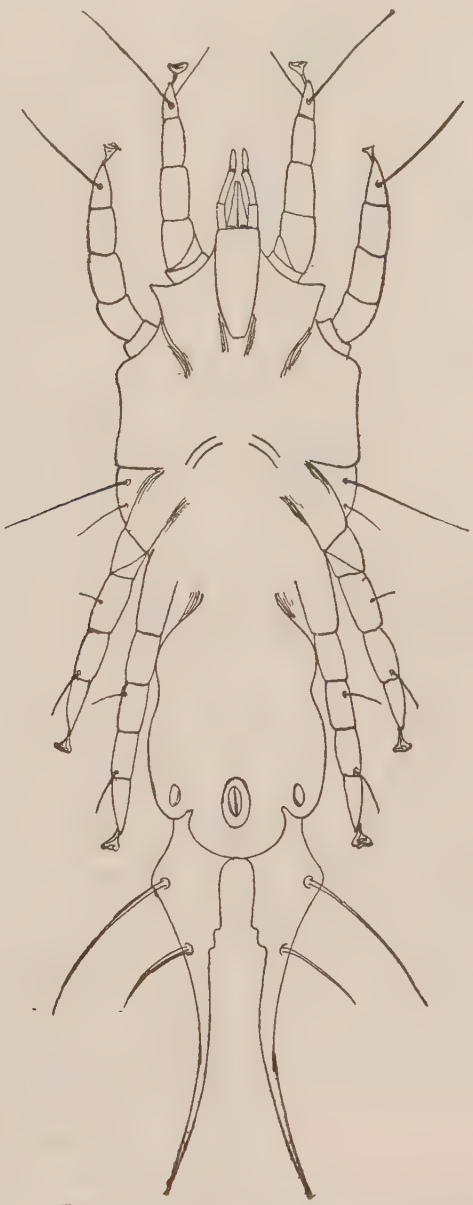


FIG. 258.—*Pterodectes armatus* (Original.)

omy, found no internal structures save a few muscles attached to the legs. From this it was evident that *Hypodectes* was a nymph in the state of histolysis. Mégnin soon made a more extended study and found that the mite was a stage in the life history of a *Pterolichus* (now placed in the genus *Falculifer*). Mégnin considers that when the *Faculifer* finds that it is being deprived of shelter and food by the birds pulling out their feathers, certain normal nymphs transform into the hypopial *Hypodectes*. This then crawls into the respiratory organs, or into the hair follicles, burrows some distance, and there remains until normal conditions are reestablished, when it reappears on the outside. However, it is probable that more is to be learned regarding these subcutaneous forms. In this country *Hypodectes* has been taken

from the pigeon and blue heron, while Mr. Beebe has recorded a similar form from various birds in the New York Zoological Park. This latter form is supposed to have caused the death of a number of birds.

In *Pteralloptes* the males have the third legs but little larger than the front legs and ending in a sucker. They have usually been taken from tropical birds.

In *Pteronyssus* the male has the third pair of legs much longer than the fourth, which is very small. The tip of the abdomen is nearly truncate in both sexes, but in the male there is often some indication of two lobes. Three species have been described from Canada: *Pt. simplex* Haller, on the red-breasted woodpecker; *Pt. speciosus* Tyrrell, on the sapsucker, and *Pt. tyrrelli* Canestrini (fig. 256) (*fuscus* Tyrrell) on the white-breasted swallow. One species, *P. bifurcatus* Hall, has been described from California. *Megninia* is similar to *Pteronyssus*, but there are several spines near the tip of the third legs, and the tip of the male abdomen is distinctly bifid. They are usually brown in color, and many species are known. Several are described from our birds, as follows:[1] *M. aculeatus* Haller, on the blue jay; *M. tyrrelli* Haller, (fig. 254), on the catbird; *M. gladiator* Haller, on the wild pigeon; *M. forcipatus* Haller, on sandpipers; *M. pici-majcris* Buchholz, on the big sapsucker, and *M. albidus* Tyrrell (fig. 255), on the white-breasted swallow.

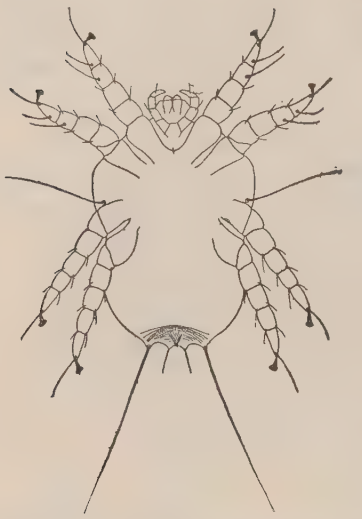


FIG. 259.—*Rivoltasia bispinosa.* (Original.)

In *Analges* the male has the third pair of legs not only longer than the others, but usually very much enlarged in the middle, sometimes enormously so. On legs I and II there are one or two spurlike projections from the tibiæ and tarsi, and on the base of the femur there is a reflexed spur, the olecranon process. The tip of the male abdomen is often pointed and never deeply bilobed; the female has a rounded tip and elongate body. The tarsal suckers are smaller than in *Megninia* and *Pteronyssus*. Five species have been described from American birds: *A. tyranni* Tyrrell, on the kingbird; *A. longispinosus* Tyrrell, on the snow bunting; *A. tridentulatus* Haller, on the horned lark; *A. cremidonotus* Trouessart, from California; *A. digitatus* Haller, on the Canadian warbler; and the European *A. passerinus* (figs. 252, 253) Linnæus, recorded from several small birds.

FIG. 260.—*Schizocarpus mingaudi:* Female, side view. (Author's illustration.)

FAMILY LISTROPHORIDÆ.

The members of this family ("Sarcoptides gliricoles" of Mégnin) are closely related to the bird mites, but live upon many of the smaller mammals, including bats. From their habits they are known as "hair-clasping mites." They are small, soft-bodied, and with short and stout legs, terminating in a sucker and often a slender claw. The body usually tapers a little behind, and the legs are widely separate, one from the other; sometimes each pair is at an equal distance from the adjoining ones. The dorsum has a few short hairs, with longer ones at tip. The surface is usually transversely striate. The rostrum or beak forms a distinct cone on the front of the body; the palpi are simple, filiform, and lie close to the underside of the beak; they are

[1] Several of these species, namely, those described by Prof. Haller in the Zeitschr. f. wiss. Zoologie, 1882, are not mentioned in Prof. Canestrini's treatment of the world species in Das Tierreich, Lief. 7, 1899.

three-jointed. The mandibles are commonly chelate, but very small. The genital aperture is situate between the third and fourth coxæ, and the anus at the tip of the body. The males, which are usually of a different shape than the females, have a pair of copulatory suckers near the tip of the venter.

These mites feed on the hairs of small mammals, and each genus has some special apparatus wherewith to hold onto the hair. In *Listrophorus* the under lip is expanded on each side into a flexible plate which curls around the hair. They occur on rabbits, squirrels, and mice. In *Myocoptes* (fig. 262) the hind pairs of legs are enlarged, the apical joints provided with a few large spurs, and these joints can fold back on the basal joints, as a knife blade. By this arrangement they cling to the hair of mice. In *Trichoecius* the hind tarsal joint is flattened, curved, and provided with a spine, which enables the mite to grasp the hair of mice. In *Labidocarpus*, which occurs on bats, the anterior legs are very short and the last joint enlarged and concave below; by these they clasp hairs. The hind legs are normal. *Schizocarpus* has a similar arrangement; it occurs on the beaver. In *Chirodiscus* the anterior legs have the apical joints flattened and curled, but destitute of claws and sucker.

FIG. 261.—*Schizocarpus mingaudi:* Male and female together. (Author's illustration.)

Each species is restricted to one or two hosts, as the clasping apparatus is fitted to hold a hair of a certain diameter and can not hold to hairs much smaller or greatly larger than those of its normal host. Little is known regarding their life history. In *Labidocarpus* the male mates with a nymphal female (as in the true Analgesidæ), which molts, and the true female issues only to deposit eggs. Some species of *Listrophorus* are preyed upon by species of *Cheyletus* that use the rabbit's fur as a hunting forest.

This family is based on the pilicolous habit and the possession of some apparatus for use in clinging to the hair. Since this apparatus is very different in the various

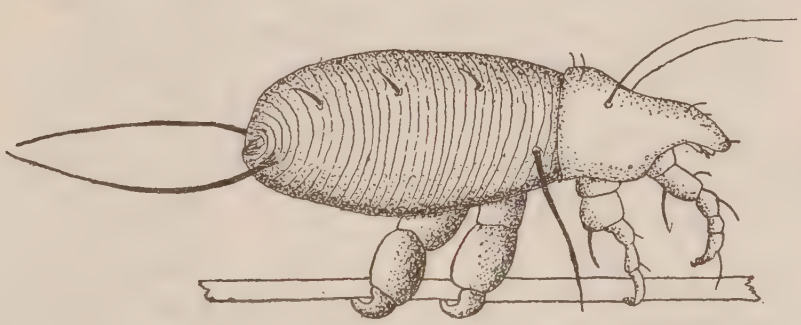


FIG. 262.—*Myocoptes* clinging to a hair. (Original.)

genera it has been surmised that the family is not a natural one, but includes forms really belonging to the Analgesidæ, Tyroglyphidæ, and Sarcoptidæ.

The American forms, with the exception of *Schizocarpus mingaudi* Trouess. (figs. 260, 261) on the beaver, *Listrophorus validus* Banks (fig. 263) on the muskrat, and *L. gibbus* Pagenst. on the rabbit, have not been investigated The former species is, however, very peculiar in many ways. The male has the third pair of legs large, the fourth very small, and mates with a nymphal female, which possesses but one pair of legs. The adult female is of normal appearance. It has been taken in Texas, California, and Washington, and also occurs in Europe.

Labidocarpus has an elongate, tapering body, annulate with many narrow ridges, and at once reminding one of the Eriophyidæ, to which there is, doubtless, some affinity.

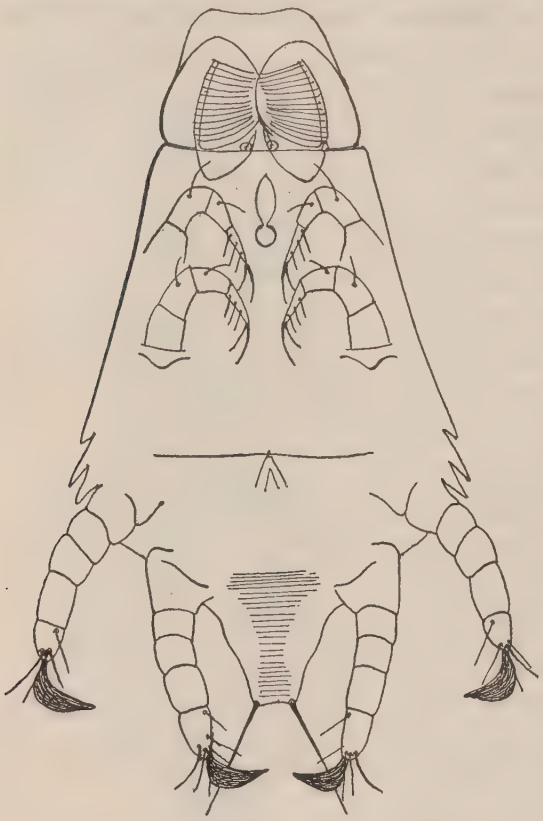


FIG. 263.—*Listrophorus validus.* (Original.)

FAMILY SARCOPTIDÆ.

The itch mites ("Sarcoptides psoriques" of Mégnin) have long been familiar through their disgusting parasitism of the human subject. They often burrow within the skin of man and other mammals, and thereby produce intense itching, and a diseased condition known as scabies, mange, or more properly acariasis. The mites are very small, white, and semiglobular in shape. The body is entire, and the surface transversely striated and provided with a few bristles, often short, stout, and sharp pointed. The legs (fig. 266) are short and stout, arranged in two groups. The anterior legs are usually larger than the others. The tarsi commonly terminate in a stout claw. There is generally a long pedicellate sucker, sometimes with a jointed pedicle. The claw or sucker may be absent and in its place a long bristle. The legs often show a chitinous framework of rings, both transverse and oblique. On the front of the body is a prominent beak. The palpi are small, three-jointed. and appressed to the sides of the beak

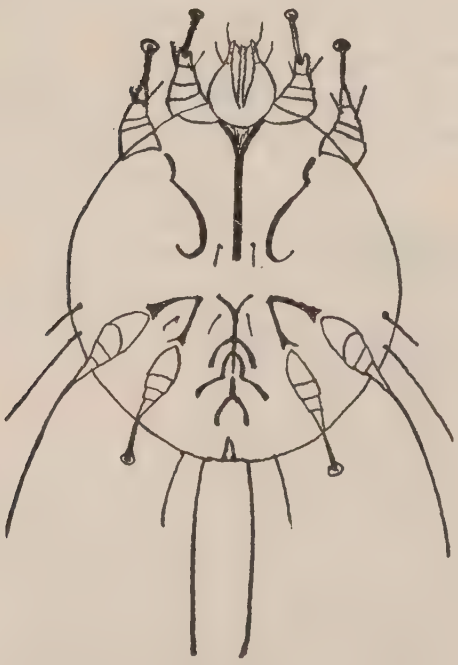


FIG. 264.—*Sarcoptes scabei:* Male. (Author's illustration.)

FIG. 265.—*Sarcoptes scabei:* Female. (Author's illustration.)

beneath. The mandibles are chelate [1] and vary in length with the genus. The ventral openings are in the usual position, and in the male there is often a pair of

[1] Fürstenberg in his great work, Die Krätzemilben Menschen, figures two pairs of chelate mandibles. This is a manifest error and weakens one's faith in his fine figures.

copulatory suckers near the tip. There are frequently sexual differences. Some males have the third pair of legs very large and long, while the fourth pair is very small. Sometimes there are platelike lobes at the tip of the male abdomen, and the tarsi may terminate differently in the two sexes. The Sarcoptidæ live in the skin of mammals, including man, and a few species of birds. The female burrows into the skin, depositing eggs on the way. The young, on hatching, start burrows of their own, so that a host is infested in patches. These burrows or cuniculi are close to the surface, and sometimes result in loosening pieces of the epidermis so as to produce a scaly effect or crust. Frequently there are vesicles, palpules, or pustules, which may become ulcerated by scratching. The different species produce different effects, and even the same species when on different animals. When upon a hairy animal, the hair usually falls out in the affected portion.

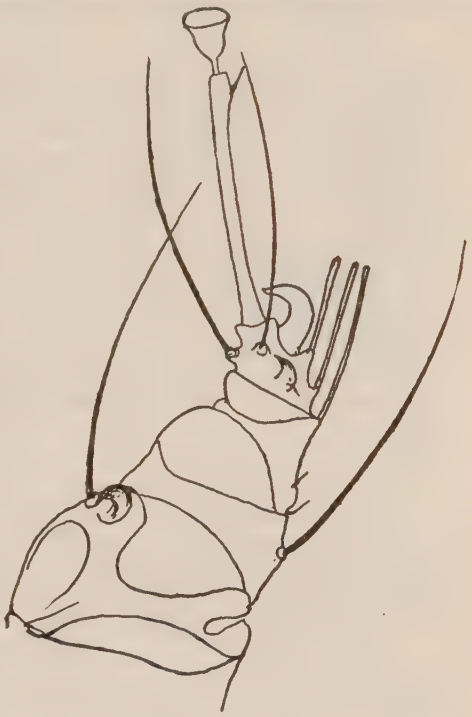


FIG. 266.—Leg of a *Sarcoptes*. (Author's illustration.

The young *Sarcoptes*, when newly hatched, has but three pairs of legs; the last ending in a long bristle; and there are no chitinous bands. Some species molt four times before maturity. When adult they pair, and the female wanders a little in search of a good burrowing place. At this time the mites can exist for a long period if removed from their hosts and kept in a moist situation; but if exposed to dryness they soon die. The burrow is made by eating the tissue, and is of the size of the mite. As the female (fig. 267) progresses she leaves behind her a row of from 10 to 40 large eggs and a considerable amount of "frass." The female, having deposited her complement of eggs, dies at the end of her burrow.

FIG. 267.—*Sarcoptes* in her burrow, and eggs. (Author's illustration.)

As the skin of the host is always wearing off and constantly being renewed from below, the eggs, when ready to hatch, will be close to the surface, so that the mites may readily escape. Above each burrow there is often a little pimple, containing a watery fluid. There appears to be no means of distribution from individual to individual except by contact. Many of the species that are normally confined to one host can live on other animals and on man. The eggs if kept moist may retain their vitality for a week.

There are only a few genera; the better known ones may be tabulated as follows:

1. Anal opening on the dorsum 2
   Anal opening below 3
2. On small mammals, not bats; third pair of legs in male without apical suckers ..... *Notoedres.*
   On bats; third legs in male with suckers ..... *Prosopodectes.*
3. Pedicel of suckers jointed; mandibles styliform and serrate near tip ..... *Psoroptes.*
   Pedicel not jointed; mandibles chelate 4
4. No suckers to legs of females; parasitic on birds ..... *Cnemidocoptes.*
   Suckers at least on legs I and II; parasitic on mammals 5
5. Legs very short; in male the hind pairs equal in size; body usually short. *Sarcoptes.*
   Legs more slender; in male the third pair is much larger than the fourth; body more elongate 6
6. Female with suckers to fourth pair of legs ..... *Chorioptes.*
   Female without suckers to fourth legs 7
7. Hind part of male abdomen with two lobes ..... *Caparinia.*
   Hind part of male abdomen without lobes ..... *Otodectes.*

FIG. 268.—*Psoroptes communis* var. *ovis:* Male. (Author's illustration.)

FIG. 269.—*Psoroptes communis* var. *ovis:* Female and caroncle enlarged. (Author's illustration.)

Sarcoptes includes the species parasitic on man, although some other genera may sometimes attack him. The human species is *S. scabei* De Geer (figs. 264, 265). This pest was formerly more common than now, particularly in armies. The intolerable itching caused by the presence of these mites leads to wild and incessant scratching, which only serves to spread the infection and increase the inflammation. Cleanliness is the best preventive. The best remedy is the use of an ointment containing sulphur. If the affected parts are freely bathed in hot water and soapsuds the scaly portions of the skin will be removed, and then the ointment can be applied with a certainty of reaching the mites. The application should be repeated two or three times, each a

few days apart, in order to kill any mites that may have hatched since the first application. All underclothes and bedding should be washed in boiling-hot water. The Norwegian itch mite is *S. scabei-crustosae* Furstb. It produces a coarse, leprous crust infested on the inner surface with myriads of the mites. It is much less common than the other species.

Nearly all of the domestic animals may harbor a species of *Sarcoptes* peculiar to them. The more common are those of the hog, horse, and sheep. They work like the human species, and are amenable to the same treatment, or that used for sheep scab.

The species of the genus *Psoroptes* have piercing mandibles, and do not burrow. One species, *P. communis* var. *ovis* Hering (figs. 268, 269), is the cause of sheep scab, a serious disease of this animal throughout the world. The fleece of scabby sheep presents a rough appearance, the wool in places being stuck together in greasy masses. The mites are most abundant around the edges of an infested patch and increase very rapidly. The eggs hatch in 2 or 3 days, and in 15 days they become mature. The female lives for several weeks and deposits a great number of eggs, commonly in patches of about 20 each. By rubbing against posts, trees, and fences patches of wool, containing mites and eggs, are removed which may infest healthy sheep rubbing against the same places from other causes. The loss is usually heaviest in autumn and early winter. Sheep if not treated may soon become so enfeebled through fatigue and lack of rest as to die. The best remedy is to dip the sheep in some poisonous solution.

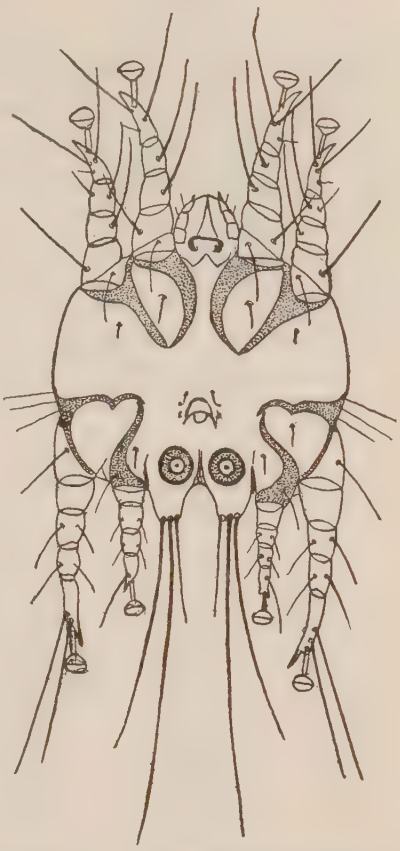


FIG. 270.—*Chorioptes setiferus.* (Original.)

Various dips are in use, mostly based on tobacco, sulphur, tar, or lime. The famous Rutherford dip, which has been very successful, is prepared by using 1 pound of tobacco, 1 pound of sulphur, and 4 gallons of water. The tobacco is steeped for some time in water, the sulphur is added to this tobacco water, and then the mixture is diluted by the requisite amount of water. It is best used warm. It is customary to give another dip about 6 or 8 days after the first, so as to catch the mites that have hatched since the first dip was applied. Gillette has used an 8 per cent kerosene emulsion, and considers it cheaper than anything else. It is said that in Europe shepherds apply a salve containing mercury and oil of turpentine. If the sheep have been kept in stables, these should be cleaned, the surface soil removed, and the woodwork whitewashed to a height of 4 feet.

FIG. 271.—*Notoedres muris.* (Original.)

The species of *Chorioptes* (fig. 270) do not burrow in the skin, but produce a scab similar to sheep scab; but it is restricted to certain parts of the animal, as the feet, the ears, or the neck. Species occur on the horse, ox, sheep, and goat. *C. equi* Gerlach attacks the hocks of horses, causing the hair to fall out, and later sores, which cause the animal much annoyance. A mixture of 1 part carbolic acid to 15 or 20 parts of oil will destroy the mite. In Australia, Froggatt has noted that the mites attack patches of white hair by preference. The genus *Notoedres* (fig. 271), differing from *Sarcoptes* in the dorsal anus, occurs on cats and

rabbits. *Prosopodectes* is limited to bats, and burrows in the tissues of the ears. *Caparinia* occurs on a few wild animals, and *Otodectes* lives in the ears of dogs and cats; *O. cynotis* Hering (figs. 272, 273) has been taken in this country. Animals may be so tormented by these parasites that they have convulsions or fits. The purulent matter should be carefully removed, and the ears bathed and injected with olive oil containing one-tenth part of naphthol.

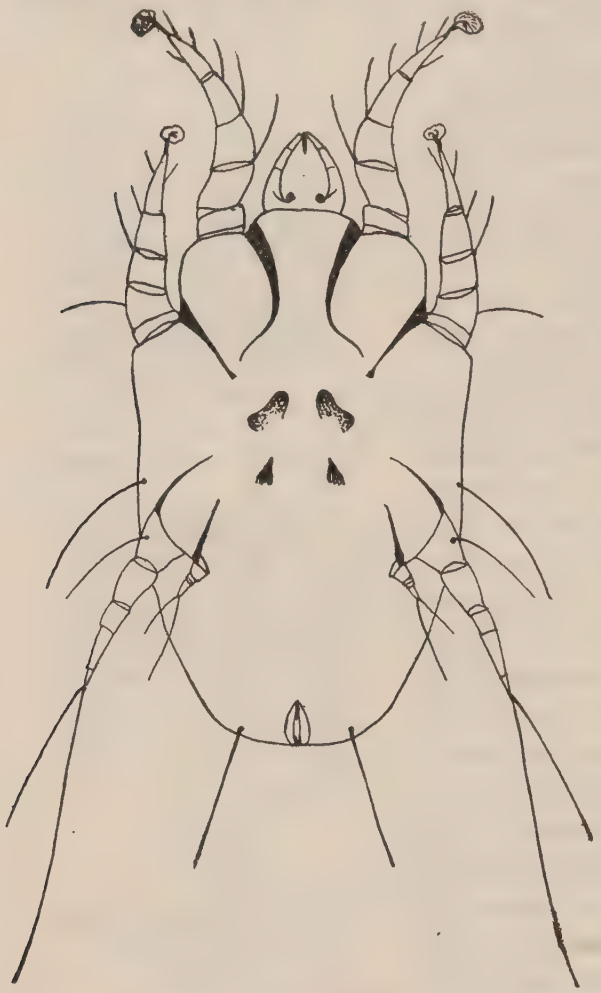


FIG. 272.—*Otodectes cynotis:* Female. (Author's illustration.)

The genus *Cnemidocoptes* contains a number of species that occur on various birds, including poultry. Some live at the base of the feathers, others produce a crust of loosened tissue and dead skin similar to that of Norwegian itch. They may begin on the comb or skin of the feet, but gradually spread down the neck or up the legs. The species are all short and broad, with short legs and with very few hairs above, and these small. They give birth to living six-legged larvæ, which, however, appear to have hatched from eggs while in the body of the parent. *C. mutans* Robin (fig. 274) is the itch mite of domestic fowls, at times a very serious pest. The disease it produces is known as "scaly leg," since the mites are most abundant on the legs. The best remedy is to soak the legs in warm soapy water until the crusts are loosened; then apply sulphur ointment. Bathing the affected portions in a solution of some coal-tar creosote preparation is also a good remedy; the treatment should be repeated in a few days. Another remedy is to dip the feet in a mixture of kerosene (1 part) and linseed oil (2 parts). The infested fowls should be isolated until cured. Another species,

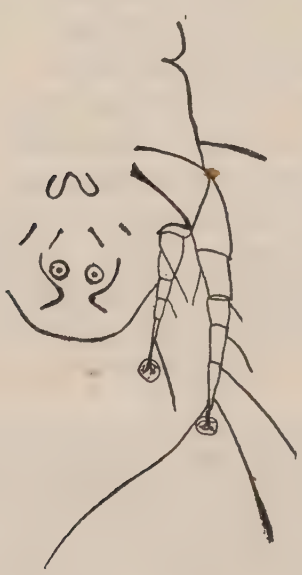


FIG. 273.—*Otodectes cynotis:* Tip of male abdomen, and hind legs. (Author's illustration.)

FIG. 274.—*Cnemidocoptes mutans:* Female. (Author's illustration.)

C. gallinæ Raillet, occurs at the base of the feathers, where it burrows and produces a mass of loosened scales. The itching induces the hens to pluck their feathers. Sulphur ointment and balsam of Peru are good remedies.

Family CYTOLEICHIDÆ.

This family ("Sarcoptides cysticoles" of Mégnin) contains but two or three species. *Cytoleichus* (formerly *Cytodotes*) *nudus* (fig. 275) and *Laminosioptes* (often *Symplectoptes*) *cysticola* (fig. 276) are of economic importance. They were discovered and described in 1870 by Francesco Vizioli in the common fowl. Both are very small, soft-bodied mites, much like a *Sarcoptes*, but differing in having the vulva longitudinal and smaller and less prominent mouth parts. The legs are very short, the anterior pairs the larger, and all separate at base. The tarsus ends in a long sucker, but without claws. *Laminosioptes* sometimes occurs on the skin, but often bores into the subcutaneous tissue, where it gives rise to a calcareous cyst. *Cytoleichus* has been found in

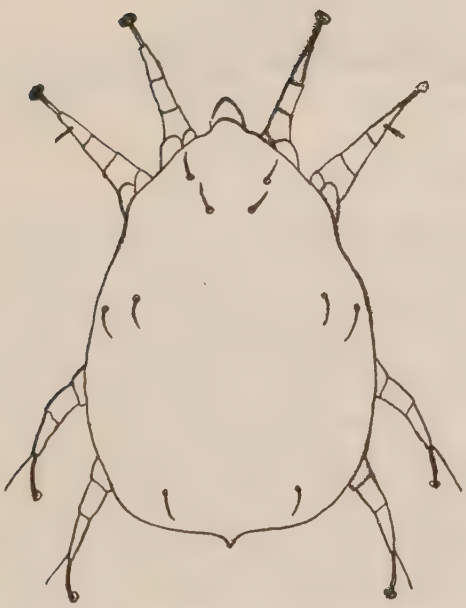


Fig. 275.—*Cytoleichus nudus*. (Author's illustration.)

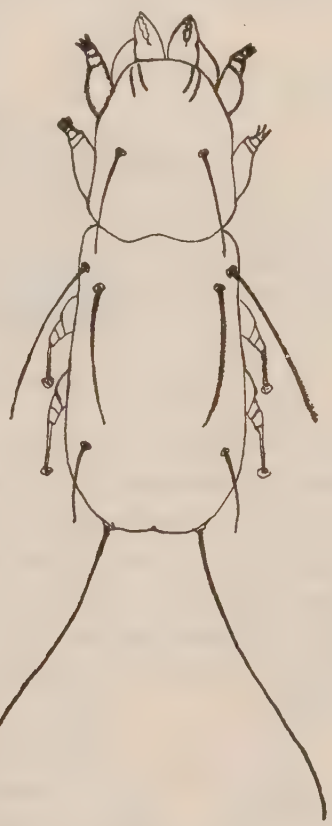


Fig. 276.—*Laminosioptes cysticola*. (Author's illustration.)

various parts of the common fowl, but most commonly in the air passages and air cells. Here its presence in great numbers may produce asphyxia in the host. It has also been suspected of producing peritonitis and enteritis, but Wilcox has shown its presence in perfectly healthy fowls, so that it is not certain that the mite necessarily produces any disease. The mites are probably taken up by the fowl with its food. Although apparently clumsy, the mite is exceedingly active, and can penetrate most of the tissues of the body. It is viviparous, and the young at birth have six legs. They also occur on most of the birds related to or associated with poultry. Both species have been taken in this country, but *Cytoleichus* is the more common. Sprinkling coal oil or naphthalene about the poultry house has been suggested as a remedy. *C. nudus* Vizioli has been found abundantly in turkeys; another species, *C. banksi* Wellman, has recently been described from squirrels in California. *Laminosioptes* has strong chelate mandibles; those of *Cytoleichus* are small and weak, and barely chelate. *Laminosioptes* has the body plainly divided, while *Cytoleichus* has the body entire, and there is a stout, erect spine on the last joint of the second pair of legs.

Superfamily DEMODICOIDEA.

Family ERIOPHYIDÆ.

The members of this family, long known as Phytoptidæ [1] are among the most curious forms of the Acarina. They are extremely minute, but make up by their great numbers. They are strictly plant feeders, and many of them cause galls, fuzzy spots, or other deformations on plants. These galls, unlike many insect galls, have an opening through which the mites may pass. The adult mite (fig. 277) has but four legs, all near the anterior part of the body, the posterior pairs being wholly lacking or represented by fine hairs. The body is divided into two parts—the anterior, short and broad, is the cephalothorax; the posterior, long, tapering, and multiannulate, is the abdomen. There are a pair of free three-jointed palpi, and between them the rostrum, from which may project the needlelike mandibles. Near the base of the abdomen, beneath, is the genital opening, the female epigynum being quite large and prominent; the male epiandrum is much smaller. At the apex of the abdomen is a truncate piece,

Fig. 277.—*Eriophyes* sp., side view. (Author's illustration.)

the telson, from which arise two long hairs, the caudal setæ, and sometimes other shorter ones. There are also a few other hairs on the body arranged in pairs (usually five) and useful in distinguishing species. At the tip of the abdomen is a sucker formed of two semicircular flaps which can be extended or retracted at the will of the animal. The legs are five-jointed, short, and end in a single tarsal claw, beneath which is a plumose hair, known as the "feather hair." The cephalothorax often shows various lines or ridges. The number of rings or annulations on the abdomen varies according to the species, and in some forms there are more divisions above than below. In size few of the Eriophyidæ reach one one-hundredth of an inch, and many are not half so long.

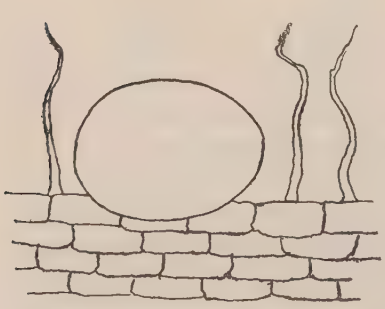


Fig. 278.—Egg of an *Eriophyes* in gall. (Author's illustration.)

The Eriophyidæ have had a checkered history. The early botanists, unable to see the minute creatures, supposed that the galls and fuzzy spots were fungi and so described them, the genus *Cephaloneon* being founded on distinct galls, *Volvolifex* on rolled edges of leaves, and *Erineum* and *Phyllerium* on the fuzzy patches.

In 1832 Dugès, who was the first to look carefully into these galls, supposed that the mites were immature since they had but two pairs of legs. He saw the eggs (fig. 278), but supposed that the adult mite had come into the gall to lay the eggs and then went out to deposit eggs elsewhere. In 1851 Dujardin examined some galls, found the mites, and noticed within some of them objects which he took to be eggs.

[1] The change of name of this well-known group of mites seems inevitable, although much to be deplored. *Eriophyes* Siebold has a year's priority over *Phytoptus* Dujardin. But Siebold did not carefully study these mites at all and supposed them to be immature creatures. Dujardin recognized their true nature and made many careful observations upon them. European authors, however, have recently adopted *Eriophyes*.

Therefore he believed these mites to be adults and named them *Phytoptus*. A few years later Scheuten examined the pear-leaf blister, found the mites, and decided that they were immature forms and that the full-grown creature was an eight-legged mite that he found associated with them. This supposed adult he figured, and it proves to be a parasitid, which was doubtless feeding on the *Eriophyes*. Since then many observers have examined these mites and confirmed Dujardin's conclusion that they are adult and constitute a separate group of acari.

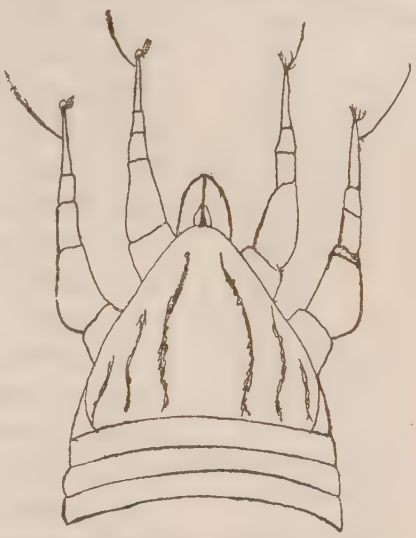


FIG. 279.—*Eriophyes gossypii:* Anterior part of body. (Author's illustration.)

The deformations produced by mites on plants have been called "acaro-cecidii." Nearly all such deformations are produced by members of this family. The relation of the mite to the gall or erineum is not fully known. An erineum is practically a dense mass of deformed hairs. These hairs are usually thickened and twisted and the whole mass is of an even height. The mites live among these deformed hairs, sucking the juices of the leaf. As the juice becomes exhausted the erineum becomes reddish or rusty brown in color and is a very prominent object. At this stage, when the erineum is most easily noticed, one is apt to find few if any mites as they have left for fresh pastures. The galls may be on either surface of the leaf, though commonly above. The form is quite characteristic of the species, though there is usually some variation. These galls always have an opening through which the mites can pass. This character will distinguish these galls from those of Diptera and Hymenoptera, but not from homopterous galls. The opening is often very small and concealed by tufts of hairs. Within the gall is often partly filled up with folds and projections and sometimes with hairs. In color the gall is at first like the leaf, but gradually turns yellow or reddish and then brown or black. Sometimes the gall covers a great deal of space but does not swell up much, being in appearance much like a blister. Galls are formed while the leaf is growing rapidly. It is supposed that the puncture of the plant cells by the mite induces an increased flow of sap in that direction, which causes the spot to grow faster than the surface around it, so that this spot must swell up in the form of a gall. This does not account for the diversity of form of the galls nor explain why each gall is characteristic of the mite that made it.

FIG. 280.—Dimple gall. (Original.)

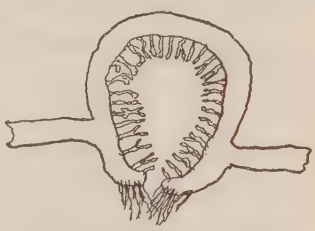


FIG. 281.—Capsule gall. (Original.)

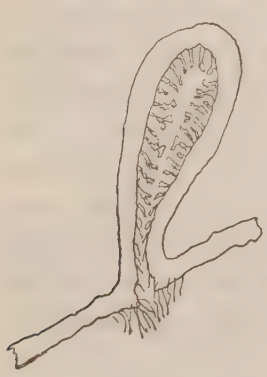


FIG. 282.—Pouch gall. (Original.)

Some species of Eriophyidæ live in plant buds, and their feeding prevents the opening of the bud, which after a time dries up and dies. With other species the buds swell to a great size, but never open. Other mites produce a curling or rolling of the edge of the leaf or a slight folding of the surface. Some live on the surface of fruits, as the orange rust mite. A few species produce galls or excrescences on twigs, especially near the base of the terminal buds.

The diseased condition produced by these mites has been termed phytoptose or erinose. Sometimes the stems are deformed into long, slender filaments, making a broom-shaped object, commonly called "witch's broom" in England. One occurs in this country on the hackberry. It is probable that the shape of the gall is dependent upon a secretion of the mite, since in some cases two species of mites occur

on the same plant and produce galls of different shape. These galls are of various shapes, according to the species of mite, and in general those on leaves may be classified in groups. Some, a simple erineum (fig. 287) or "frost gall"; in others the area of the erineum is depressed, making a "dimple gall" (fig. 280); in others this depression becomes deeper and the margins grow toward each other, making a "round" (fig. 288) or "capsule gall" (fig. 281). The round gall may become elongate, forming a "pouch gall" (fig. 282); or become flattened, making a "blister gall" (fig. 284); or may lengthen into a pointed process and is then called a "nail gall" (figs. 283, 285). Swellings along a vein are termed "rib galls" (fig. 286).

FIG. 283.—Nail gall. (Original.)

The eggs (fig. 278) of the Eriophyidæ are laid upon the surface of the leaf, sometimes before the leaf has opened. They are attached singly, are nearly spherical in shape, and pale yellowish or grayish in color. The eggs are quite large as compared with the mite. The young, at birth, are helpless and without tarsal appendages, but soon molt and obtain them. The mites can move quite swiftly, considering their size, and sometimes they spread over a tree with wonderful rapidity. The anal sucker aids them in holding onto a surface, but not in locomotion. They molt four times, it is said, before becoming adult, but pass through no changes in structure, except the development of the genital apertures. At each molt there is a resting period when the mite is within its old and now loose skin. With the drying up of the food plant in the fall the mites seek winter quarters within the buds or beneath the bud scales. Sometimes, doubtless, they winter under pieces of bark. When in a bud they begin to feed on the leaf and produce the gall before the bud is fully open.

FIG. 284.—Blister gall. (Original.)

The Eriophyidæ are, perhaps, more closely related to the Tarsonemidæ than to any other group. Many of the Tarsonemidæ feed exposed on leaves or stems of a plant; some of them cause swellings or deformities of the plant, and some have the body more or less distinctly segmented. Moreover, in several genera of Tarsonemidæ there is a tendency to the reduction in the number of the legs, and in other genera the hind legs are very slender and of little use in walking.

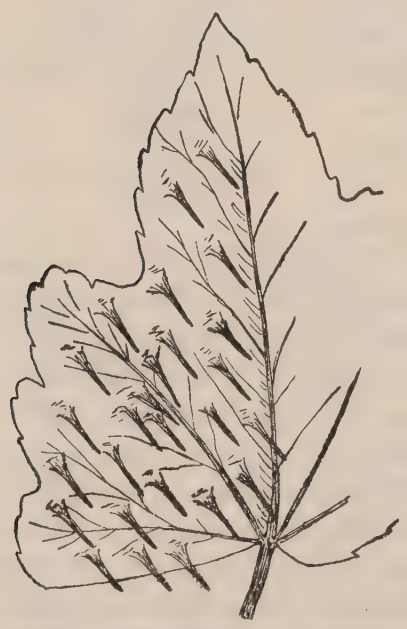


FIG. 285.—Nail galls of an *Eriophyes*. (Author's illustration.)

The few tropical species known belong to the common European genera, their galls are similar to those of the temperate zone, and several of our species are identical with European forms. There is not much diversity of form in the family, and generic classification is based on few and rather simple characters. Quite a number of galls have been collected in the United States, but the mites have not been studied except by Profs. Garman and Hodgkins, who have described a few species. Several European acarologists have carefully studied these mites in recent years, but the work of Alfred Nalepa has been preeminent.

The better-known genera may be separated as follows:

1. Number of abdominal rings on dorsum and venter nearly equal..... *Eriophyes*.
   Number of abdominal rings on venter nearly twice as many as on dorsum... 2
2. Dorsum with the middle area highly arched..... 4
   Dorsum of an even curve..... 3

3. End piece of abdomen plainly separated..... *Anthocoptes.*
   End piece of abdomen not plainly separated..... *Phyllocoptes.*
4. Some of the dorsal abdominal rings extend backward spinelike on the side ..... *Oxypleurites.*
   Dorsal rings not so..... 5
5. Dorsum of abdomen with two longitudinal furrows..... *Epitrimerus.*
   Dorsum without furrows..... *Tegonotus.*

Most of the species, so far known from the United States, have been referred to *Eriophyes*, but several of the other genera occur here. The most notable of all our species is the pear-leaf blister mite, *Eriophyes pyri* Pagenstecher, an European species whose introduction into this country seems to have been accomplished before 1870. It is now widely distributed throughout the pear-growing region, and also occurs in Australia. It appears to be more injurious in this country than in Europe, and in some cases it is so abundant that the tree sheds nearly all its leaves before the fruit is ripe. The mites pass the winter in the buds, and begin to feed before the leaves are unrolled. They form red blisterlike spots nearly one-fourth inch across. These spots become green by June, and then turn brown, and the tissue becomes hard and corky. The opening is on the under side. As mites often start galls close together, they soon coalesce and form large blotches. Prof. Slingerland has found that they can be practically exterminated by spraying the trees in winter with kerosene emulsion diluted with from 5 to 7 parts of water. This mixture reaches the hibernating mites in the buds and kills them there. The pear-leaf blister mite also occurs on apple leaves. The galls often contain other species of mites, three of which, *Phyllocoptes schlechtendali* Nalepa, *Epitrimerus piri* Nalepa, and *Eriophyes malifoliae* Parrott, have been found in these galls in our country.

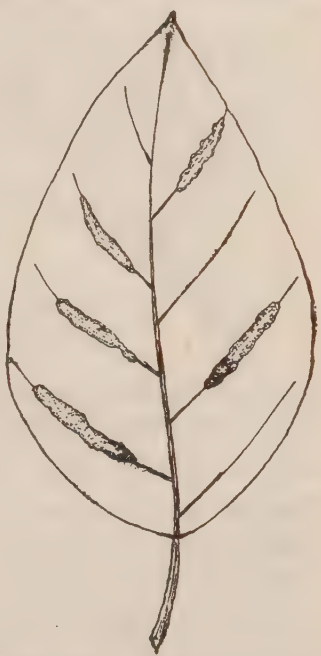


FIG. 286.—Rib galls of an *Eriophyes*. (Author's illustration.)

Another species of considerable economic importance is *Phyllocoptes oleivorus* Ashmead, the rust mite of the orange and the silver mite of the lemon. It occurs in Florida and California and lives on both leaves and fruit. On the foliage the mite causes the leaves to become curled and lose their gloss. On the fruit of the orange the mite produces a hardening of the rind, which becomes brownish in color. The infested orange, although injured in appearance, is better able to stand long shipment and is more juicy than the clean fruit. Upon the lemon the mites cause the rind to become whitened or silvered. The fruit is better for shipment, but the rind is injured for commercial purposes. The spherical eggs are deposited on the leaf or fruit, generally in clusters. They hatch in 5 to 10 days. It takes about 2 weeks to reach maturity. Its food is the essential oil, found in the epidermal cells. Mr. Hubbard, who studied this mite more carefully than anyone else, estimated that there may be 75,000 mites and eggs on a single leaf. The best remedy is flowers of sulphur, which may be applied dry or mixed in with a spray solution, as kerosene emulsion.

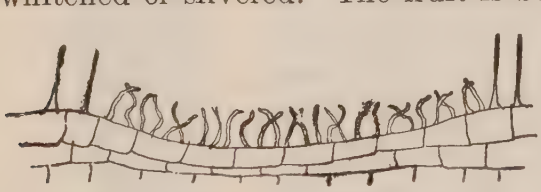


FIG. 287.—Section of an erineum on leaf. (Author's illustration.)

Another *Phyllocoptes*, *P. schlechtendali* Nalepa (fig. 290), is of economic importance, as it often occurs on pear, blackening and curling the leaves. It also occurs on other kinds of fruit trees. It is larger and much broader than the pear-leaf blister mite.

Phyllocoptes amygdalina Banks occurs on the leaves of Davids peach in California, and another species, *P. californica* Hall, has been found on the leaves of *Artemisia*.

Another injurious species in this country is the plum-twig gall mite, *Eriophyes phloeocoptes* Nalepa (also known as *Cecidoptes pruni* Amerling). It is an European species that has been imported into this country in recent years. The mites form small subspherical galls at the base of the buds. A cluster may surround the twig. The mites hibernate within the galls, leaving them in the spring to form new ones. The galls are at first plump and smooth, but later become dry and wrinkled and sometimes crack. Pruning and burning the infested twigs in winter will keep the mites in check. An application of sulphur in the spring when the mites are active will doubtless destroy many of them.

FIG. 288.—Round galls of an *Eriophyes*. (Author's illustration.)

The black-currant gall mite, *Eriophyes ribis* Nalepa, is very injurious to the currant in England. They penetrate the buds, causing them to swell, and badly infested buds die before opening. The mites breed throughout the year. They migrate in the spring when the buds are opening and may be destroyed at this time by a wash of soft soap and sulphur. It has been observed that this species can stand upright and even jump into the air and be carried some distance by the wind.

In California the *Eriophyes vitis* Landois (fig. 289) often seriously injures the leaves of the grape. The mites produce an erineum on the under surface of the leaf that causes swellings on the upper surface. The mites pass the winter in the buds or under the bark of the vine. Applications of sulphur will destroy this as well as other species of *Eriophyes*. Erineums and galls occur on a great number of our native trees and plants. Some of the more common of these are mentioned below, but many of our forms are yet to be described, and in most cases the mites have not been studied in a careful manner. Recently Hodgkiss has described the numerous species on maples.

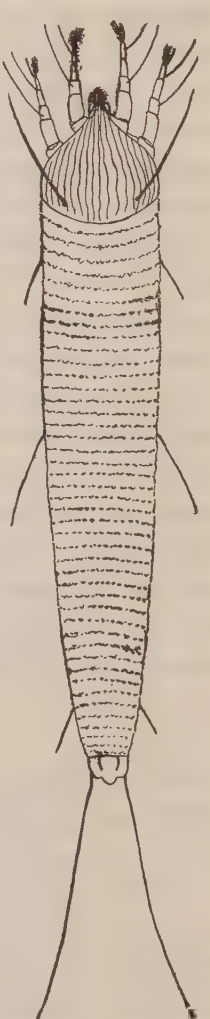


FIG. 289.—*Eriophyes vitis*. (Author's illustration.)

A small rounded gall on ash leaves is made by *E. fraxini* Garman. A deformation of the terminal buds of the white ash is caused by *E. fraxiniflora* Felt. On maples there are several galls. A simple erineum (yellowish to brownish in color) on the under surface of the leaves is tenanted by *E. ryderi* Banks. A small, irregularly rounded gall, often extremely numerous, is produced by *E. quadripedes* Shimer, and is at first green, then purplish, and finally black. Elongate pouch galls, rarely numerous, are made by *E. acericola* Garman. In the red erineum on the upper side of the leaves of sugar maple Hodgkiss has found three species of *Eriophyes*, two species of *Phyllocoptes*, and one *Oxypleurites*. In the pink erineum on the under surface of leaves of the red maple he found two species of *Eriophyes* and one *Phyllocoptes*. On oaks it can also be noted that erineums are more apt than galls to be tenanted by several species of mites. A wartlike gall on leaves of *Negundo*, or black maple, is produced by *Eriophyes negundi* Hodgkiss. In blisters on the bark of red maple Hodgkiss found a species of *Anthocoptes*.

On the black walnut and butternut there is a very dense brown erineum surrounding the leaf stalks or main veins of the leaf, caused by *E. caulis* Cook, while an erineum (usually very large) on the surface of the leaf is produced by *E. erinea* Nalepa. This

latter has been sufficiently abundant in California to be considered injurious to the trees. A small roundish gall, with many folds in its interior and the orifice guarded by long white hairs, is also found on the leaves of black walnut. The mites are red, and were described by Nalepa as *Eriophyes tristriatus*. On willows there are small rounded galls on the leaves formed by *E. semen* Walsh, and longitudinal leaf folds caused by *E. salicicola* Garman. Inrolled leaf margins are caused by an undetermined species, and large, irregular deformations of the buds are the results of *E. aenigma* Walsh.

FIG. 290.—*Phyllocoptes* sp., side view. (Author's illustration.)

Oak leaves often show an erineum on the underside, which sometimes becomes a dimple gall; on the white oak it is produced by *E. querci* Garman, while that on other oaks is probably the work of a different species. The leaves of basswood frequently have large pouch galls, which are inhabited by *E. abnormis* Garman. On the leaves of the American elm small round galls are caused by *E. ulmi* Garman. On the alder leaves there are often great numbers of small rounded galls produced by *E. brevipes* Fockeu. Pouch galls on leaves of wild cherry are made by *E. serotinae* Beutenmüller, while minute rounded galls on the leaves of the tupelo or sour gum are caused by *E. nyssae* Trotter. On the twigs and stems of poplar there are sometimes very large, irregular deformations, known to the Germans as "knospenwucherungen." This gall is produced by *E. populi* Nalepa and occurs throughout the Northern States from New England to Colorado, where it is rather common. *Eriophyes gossypii* Banks (fig. 279) occurs injuriously upon cotton in Montserrat and some other West India islands. The mites produce galls which were so numerous as to cover many leaves with a mass of irregular, roughened swellings, curled and distorted. The damage in places has been so severe that the cotton has been thrown into the sea. The galls within are densely clothed with long hairs. Two species are very injurious to the leaves of the tea plant in India and Ceylon, and no good remedies have yet been devised for them.

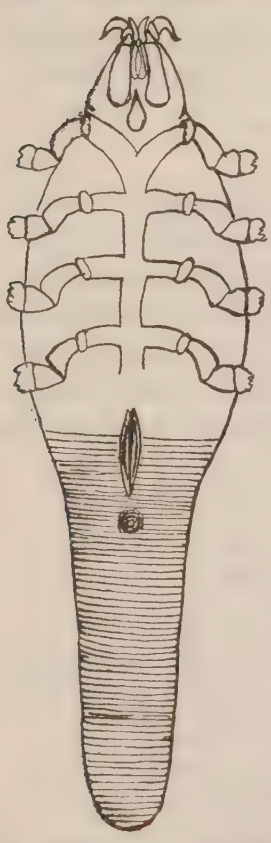


FIG. 291.—*Demodex folliculorum.* (Author's illustration.)

FAMILY DEMODICIDÆ.

To this family belongs but one genus, *Demodex*, found in the sebaceous glands and hair follicles of various mammals, including man. The mite is very small, elongate, with eight short, three-jointed legs, and in front a short, median, sucking rostrum. The palpi are appressed to the under surface of the rostrum. The abdomen is tapering, transversely striate above and below, and rounded at tip. There is a large vulva situate at base of the abdominal venter. The egg is fusiform, and gives birth to a hexapod larva, which molts and becomes octopod. Two more molts bring it to maturity. The nymphs greatly resemble the adults, and the sexes differ but little. *D. folliculorum* Simon (fig. 291), the species found on man, was long supposed to be the cause of "blackheads" and comedones on the face. Medical authorities claim that the mites do not cause "blackheads," and that they occur in healthy as well as diseased follicles. The mites migrate over the skin to enter new glands. They occur on children as well as adults, and in all parts of the world. *D. phylloides* Csokor has been found in Canadian swine, causing white tubercles on the skin, from

the size of a pinhead to that of a pea. Within each of these abscesses a number of the *Demodex* were crowded together. They did not appear to affect the health of the animal. *D. bovis* Stiles was recorded from hides of cattle in the United States. They formed swellings, about the size of a pea, on the skin. Within each there were a great number of mites. The presence of these tubercles lessens the value of the hide to a considerable degree. Herds could doubtless be cleaned by dipping in some liquid similar to the sheep and cattle dips now in use against other mites. Borrel (1909) considers that there is evidence that leprosy is transmitted by *Demodex*, but the evidence is at the most only suggestive and not conclusive; he also suggests that in some cases *Demodex* may be the vector of cancer.

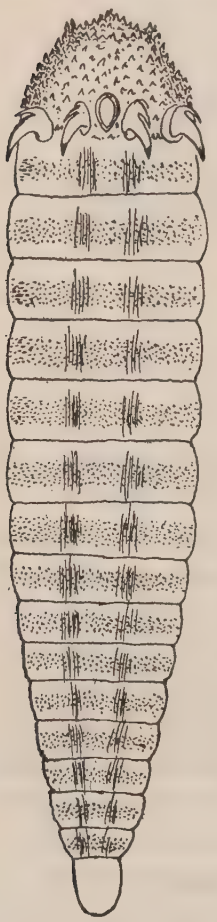


FIG. 292.—*Porocephalus* sp. (Original.)

FAMILY OPILIOACARIDÆ.

This family has been made for certain peculiar mites recently described by With as *Opilioacarus*. They have a body about twice as long as broad, with large, prominent, simple, five-jointed palpi, and long, slender legs. The front and hind legs are more than twice the length of the body. The abdomen is segmented, and bears four pairs of dorsal spiracles. The cephalothorax has two sessile eyes on each side. The mandibles are stout, two-jointed, and chelate. The two claws at the end of the tarsus are situated upon a caroncle. With considers that they represent a distinct suborder, the *Notostigmata*, but what relation they have to other mites is as yet uncertain. Several species have been described from Italy, Algeria, Arabia, and Argentina. Nothing is known of their life history or habits, except that some occur under stones.

UNCERTAIN ACARI.

Mention should be made of those groups of animals more or less closely related to mites, but whose relationships are not agreed upon by naturalists. By some they have been placed in Acarina, but the chief reason would seem to be that they do not fit into other groups. They have not been studied by acarologists nor usually considered by them as coming within their field of observation. The first, the Linguatulidæ, are wormlike creatures, usually found in the nasal cavities, lungs, or connecting passages of flesh-eating vertebrates, such as snakes, crocodiles, and carnivorous mammals. Their larvæ are found in various tissues o the prey of these carnivorous animals. The body is more or less ringed; the anterior part separated from the rest, and with a central mouth, and two pairs of hooks each side of it. The adults have no legs, but some larvæ have two pairs of leglike processes. Some of them become 2 or 3 inches long. Shipley, who has revised the group, recognized 20 species. There are two principal genera: *Linguatula* with a flattened body, and *Porocephalus* (fig. 292) with an elongate, cylindrical body.

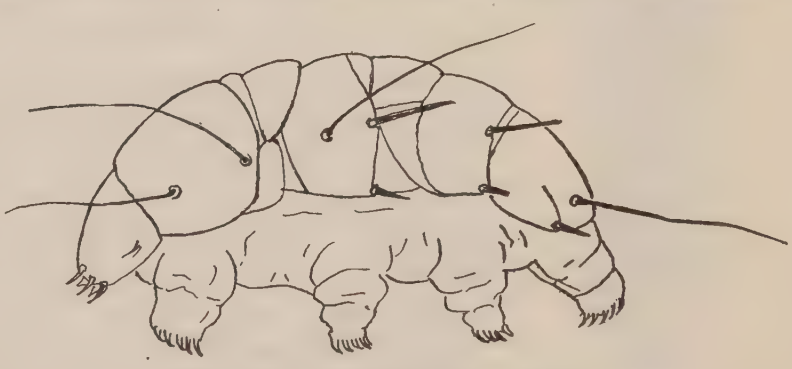


FIG. 293.—A tardigrade. (Original.)

The second group, the Tardigrades (fig. 293), or "water bears," have much greater resemblance to acari, but whether more affinity or not is a doubtful question. They

are very minute, rarely over 1 mm. long, and occur in wet moss, such as is found in old gutters, on stones, or old walls; a few live in water; two are known from salt water. Their body is apparently segmented and tipped with a pair of fleshy processes bearing apical claws. Other similar processes occur on the sides of the body, also tipped with claws. Those species that inhabit moss possess a most remarkable power of revivification. If they are gradually dried up they may remain so for years, but on the application of water they gradually revive, swell out, and begin to live again. There are about 6 genera, and many species described. In some cases the same species occurs in England and in Chile, at sea level, and up to 11,000 feet. Of the two principal genera, *Echiniscus* has dorsal shields on the body, and *Macrobiotus* is without shields and with a rather longer body. A number of species have been described from Canada.

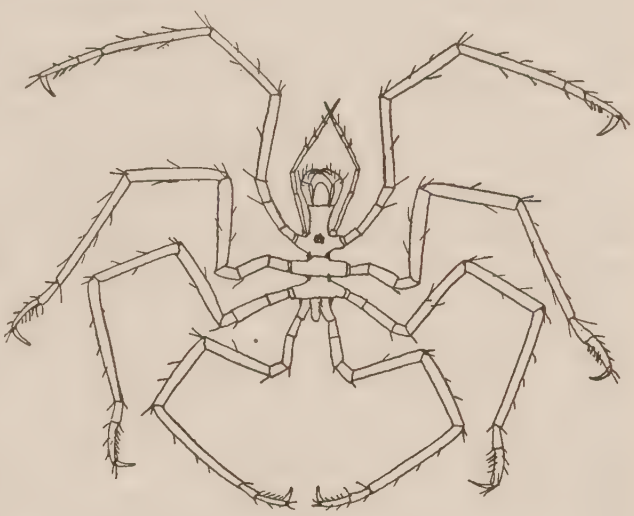


FIG. 294.—Nymphon; a pycnogonid. (Original.)

The third group, Pycnogonida (fig. 294), or "sea spiders," are slender-bodied, long-legged forms living in salt water. They have some resemblance to acari, but probably little real relationship. The fact that the best-known species had four pairs of legs suggested their association with mites, but other species have more pairs of legs; moreover, the segmented body and the character of the mouth parts are greatly at variance with acari. The male carries the egg masses attached to a special pair of legs. Many genera and species are described, some occurring under stones near low-water mark.

COLLECTING, PREPARING, AND REARING MITES.

If one desires to collect all kinds of mites, he must search every imaginable place. Many students take up some particular group, more restricted in habits; thus if one wishes to collect Analgesidæ, he must examine bird skins; if he is seeking Eriophyidæ, he walks about looking for their galls; if he is after Hydrachnidæ, with nets he must examine the water of pools and streams. In general the free-living land mites are to be found most abundantly on the ground among fallen dead leaves and in moss. This material can be sifted through a small-mesh wire sieve onto a white cloth or paper, where after a few minutes "playing possum" the mites will start to crawl away. They can be picked up by a toothpick dipped in glycerin, or by a fine camel's-hair brush, or many can be taken on the wetted point of a pair of fine forceps. Those in hard fungi can be shaken from their retreats; those under bark can be observed by use of a low-power lens; those on leaves and twigs of trees can be beaten into an inverted umbrella or piece of outstretched white cloth.

Berlese has invented an apparatus for collecting mites and small insects in large numbers. It is described and figured in Bulletin 67 of the United States National Museum. The material—decaying leaves, moss, etc.—is placed on a sieve within a funnel; the funnel is heated by a hotwater jacket; the mites, aroused by the heat, fall through the sieve down the funnel into a vial of alcohol below, placed there for that purpose. This method saves time, but one loses much of the pleasure of collecting, and fails to learn the habits of the mites in nature. All mites may be collected in alcohol of about 70 per cent. Many prefer to collect them alive and kill them by special methods which will keep the legs extended. They can be killed in hot water

and then placed in alcohol for a few hours before mounting on a slide. Many of the larger mites can be kept in small vials of alcohol and examined in watch glasses; but the smaller mites must be mounted on slides, and many students mount all of their specimens. Various media have been used for mounting mites on slides. Canada balsam has been used more than anything and is very satisfactory for most forms with a chitinous tegument. For the delicate forms many use glycerin jelly, but a mixture of it, 10 parts glycerin jelly to 1 of glacial acetic acid is considered a better medium. Before putting the specimen in balsam or glycerin it is well to clear it by use of a few drops of xylol, oil of cloves, or oil of bergamot. Care should be taken in placing the balsam or glycerin so that the resulting mount will be no thicker than necessary to prevent pressure on the specimen. Instead of keeping specimens in alcohol before mounting them, some prefer a mixture of 2 parts distilled water and 1 of acetic acid. If mounted in balsam it is not necessary to seal the mount, but if in glycerin it should be ringed with zinc-cement, Brunswick black, asphalt, or some similar material. It is not easy to rear mites in captivity. Some forms, like tyroglyphids, can be placed on a decaying surface, and if the moisture and ventilation is maintained will breed in enormous numbers. But the Oribatidæ and Parasitidæ are much more difficult. These can be kept within a small glass cell placed on a microscope slide and covered with cover glass held down by a few drops of glue, or a rubber band. Cells can be purchased, or made by cutting off sections of glass tubing of the proper size. A piece of moist blotting paper may be put in the cell, and then the mites or eggs and some food. It is necessary to see that the cell does not dry out nor become too moldy. By care many mites can be reared in such cells and their habits and transformations observed under the microscope. Ticks may be reared by placing them on a suitable animal and covering the spot with a cloth or muslin bag to catch the tick when ready to molt. The rearing of species parasitic on birds would be difficult and has not been accomplished; but those on some of the domestic birds doubtless could be studied by isolating a pair on a host in confinement.

LIST OF WORKS USEFUL IN THE STUDY OF AMERICAN ACARINA.

N. Banks. Some new American Acarina. Trans. Amer. Ent. Soc., 21, 1894, p. 209–229.

N. Banks. On the Oribatoidea of the United States. Trans. Amer. Ent. Soc., 22, 1895, p. 1–16.

N. Banks. The red Spiders of the United States. Bul. 8, Tech. Ser., Div. Ent., U. S. Dept. Agr., 1900, p. 65–77.

N. Banks. A revision of the Ixodoidea, or ticks, of the United States. Bul. 15, Tech. Ser., Bur. Ent., U. S. Dept. Agr., p. 60, 10 pls. 1908.

N. Banks. A revision of the Tyroglyphidæ of the United States. Bul. 13, Tech. Ser., Bur. Ent., U. S. Dept. Agr., p. 34, 6 pls. 1906.

N. Banks. New American mites. Proc. Ent. Soc. Wash., vol. 12, p. 2–12, 3 pls. 1910.

N. Banks. New Canadian mites. Proc. Ent. Soc. Wash., vol. 11, p. 133–143, 4 pls. 1909.

N. Banks. New Oribatidæ from the United States. Proc. Acad. Nat. Sci., Phila., 1906, p. 490–500, 5 pls.

N. Banks. A catalogue of the Acarina, or mites, of the United States. Proc. U. S. Nat. Mus., vol. 32, p. 595–625. 1907.

A. Berlese. Acari, Myriopoda et Scorpiones hucusque in Italia reperta. Patavia, 1880–1900, 6 pts. Issued in mixed fascicles; the parts on Prostigmata (Trombidiidæ), Gamasidæ, Oribatidæ, and Sarcoptoidea are finished.

A. Berlese. Monografia del Genere Gamasus Latr. Redia, III, p. 66–304, 17 pls. 1905.

A. Berlese. Illustrazione Iconografica degli Acari mirmecofili. Redia, I, p. 299–474, 14 pls. 1904.

A. Berlese. Lista di nuove specie e nuovi generi di Acari. Redia, VI, p. 242–271. 1910.

A. Berlese. Acari nuovi, Manipuli I–VII. Redia, I–VI, 1903–1910, 6 pts. Hundreds of new species from all parts of the world.

A. Berlese. Trombidiidæ. Prospetto dei genere e delle specie finora noti. Redia, VIII, p. 1–291. 1912.

G. Canestrini. Prospetto dell' Acarofauna Italiana. Padova, 7 pts. 1885–1897.

G. Canestrini and P. Kramer. Demodicidae et Sarcoptidæ. Das Tierreich, 7 Lief., 1899, p. 193.

E. Claparède. Studien an Acariden. Zeitschr. f. wiss. Zool., XVIII, 1869, p. 445–546, 11 pls.

A. L. Donnadieu. Recherches pour servir a l'histoire des Tetranyques. Ann. Soc. Linn. Lyons, XXII, 1875, p. 29–180, 12 pls.

A. Dugés. Recherches sur l'ordre des Acariens. Ann. Sci. Nat. (2), I, 1836, Zool., p. 18–63.

E. Ehlers. Die Krätzmilben der Vögel; Ein Beitrag zur Kenntniss der Sarcoptiden. Zeitschr. f. wiss. Zool., XXII, 1873, p. 228–253, 2 pls.

H. E. Ewing. The Oribatoidea of Illinois. Bul. Ill. State Lab. Nat. Hist., VII, p. 337–389. 1909.

H. E. Ewing. A systematic and biological study of the Acarina of Illinois. Bul. Univ. Illinois, vol. 7, no. 14, 1909, p. 120, 8 pls.

ANNA FOA. Esistono il polimorfismo o la partenogenesi nei Gamasidi? Bul. Ent. Soc. Ital., 1900, p. 121–149.

A. FUMOUZE and C. ROBIN. Memoire anatomique et zoologique sur les Acariens des genres Cheyletus, Glyciphagus, et Tyroglyphus. Journ. Anat. et Physiol., 1867, p. 505–528, 561–601.

H. F. FÜRSTENBERG. Die Krätzmilben der Menschen und Thiere. Leipzig (Folio). 1861, 240 p., 15 pls.

H. GARMAN. The Phytopti and other injurious plant-mites. 12th Rept. State Ent. Illinois, 1883, p. 123–143.

P. GERVAIS. Histoire nat. des Insectes Aptères. III. Paris, 1844, p. 132–288.

G. HALLER. Zur Kenntnis der Tyroglyphiden und Verwandten. Zeitschr. f. wiss. Zool., XXXIV, 1880, p. 255–295, 3 pls.

G. HALLER. Die Milben als Parasiten der Wirbellosen, insbesondere der Arthropoden. Halle, 1880, 90 p.

R. VON HANSTEIN. Beiträge zur Kenntniss der Gattung Tetranychus Duf. Zeitschr. f. wiss. Zool., Bd. 70, p. 58–108, 6 pls. 1901.

H. E. HODGKISS. New species of maple mites. Journ. Econ. Ent., VI, p. 420–424. 1913.

W. D. HUNTER and W. A. HOOKER. Information concerning the North American fever tick with notes on other species. Bul. 72, Bur, Ent., U. S. Dept. Agr., p. 87, 4 pls. 1907.

L. KARPELLES. Beiträge zur Naturgeschichte der Milben. Berl. Ent. Zeitschr., 1884, p. 1–34.

F. KOENIKE. Die Nordamerikanische Hydrachniden. Abh. Verein, Bremen, XIII, 1900, p. 167–276.

P. KRAMER. Beiträge zur Naturgeschichte der Milben. Archiv. f. Naturgesch., XLII, 1876, p. 28–45.

P. KRAMER. Zur Naturgeschichte einiges Gattungen aus der Familie der Gamasiden. Archiv. f. Naturgesch., XLII, 1876, p. 46–105, 2 pls.

P. KRAMER. Die Familie der Bdelliden. Archiv. f. Naturgesch., XLII, 1876, p. 183–196, 1 pl.

P. KRAMER. Grundzüge zur Systematik der Milben. Archiv. f. Naturgesch., XLIII, 1877, p. 215–248.

R. MARSHALL. Ten species of Arrhenuri belonging to the subgenus Megalurus Thon. Trans. Wisc. Acad., XIV (1), p. 145–172, 5 pls. 1904.

R. MARSHALL. The Arrhenuri of the United States. Trans. Amer. Micr. Soc., vol. 28, p. 85–140, 16 pls. 1908.

R. MARSHALL. New studies of the Arrhenuri. Trans. Amer. Micr. Soc., XXIX, no. 2, p. 97–108. 1910.

P. MÉGNIN. Memoire sur l'organization et la distribution zoologique des Acariens de la familie des Gamasides. Journ. Anat. et Physiol., 1876, p. 228–336, 2 pls.

P. MÉGNIN. Memoire sur les Metamorphoses des Acariens en géneral, et en particulier sur celles des Trombidions. Ann. Sci. Natur. (6), IV, 1876, p. 20, 2 pls.

P. MÉGNIN. Monographie de la tribu des Sarcoptides Psorique. Rev. et Mag. Zool. (3), V, 1877, p. 46–213; 7 pls. in VI. 1878.

P. MÉGNIN. Memoire sur les Cheylétides parasites. Journ. Anat. et Physiol., 1878, p. 416–441, 2 pls.

P. MÉGNIN. Les Acariens parasites du tissu cellulaire et des réservoirs aériens chez les oiseaux. Journ. Anat. et Physiol., 1879, p. 123–153.

P. MÉGNIN. Les parasites et les maladies parasitaires. Paris, 1880, 478 p., 26 pls.

A. D. MICHAEL. British Oribatidæ. Ray Soc., I, 1883, 333 p., 29 pls.; II, 1887, 324 p., 31 pls.

A. D. MICHAEL. The Hypopus question, or the life-history of certain Acarina. Journ. Linn. Soc., Zool., XVII, 1884, p. 371–394, 1 pl.

A. D. Michael. British Tyroglyphidæ. Ray Soc., I, 1901, 291 p.; 12 pls.; II, 1903, 183 p., 17 pls.

A. D. Michael. Oribatidæ. Das Tierreich, 3 Lief., 1898, 93 p.

R. Moniez. Notes sur quelques espèces de Tyroglyphides qui vivent aux dépens des matières alimentaires et des produits pharmaceutiques. Revue Biol. Nord France, VI, 1894, p. 442–460.

H. A. Morgan. Ticks and Texas fever. Bul. No. 56, La. Agric. Exp. Station, 1899, p. 14, pls. 9.

A. Murray. Economic Entomology, Aptera. South Kensington Museum Science Handbooks, London, 1897, p. 93–374.

A. Nalepa. Beiträge zur Systematik der Phytoptiden. Sitz. Akad. Wien, Math.-Natur. Cl., XCVIII, 1889, p. 112–159, 9 pls.

A. Nalepa. Zur Systematik der Gallmilben. Sitz. Akad. Wien, Math.-Natur. Cl., XCIX, 1890, p. 40–69, 7 pls.

A. Nalepa. Eriophyidæ (Phytoptidæ). Das Tierreich, 4 Lief., 1898, 74 p.

L. G. Neumann. Révision de la familie des Ixodidés. Mém. Soc. Zool. France, 1896, p. 1–44; 1897, p. 324–420; 1899, p. 107–294.

L. G. Neumann. Ixodidæ. Das Tierreich, 26 Lief., 1911, p. 169.

H. Nicolet. Histoire naturelle des Acariens qui se trouvent aux environs de Paris. Archives du Muséum d'Hist. nat. de Paris, VII, p. 381–482, 10 pls., 1854–55.

E. Nordenskiöld. Beiträge zur Kenntnis der Morphologie und Systematik der Hydrachniden. Acta Soc. Sci. Fenn., XXIV, no. 5, 1899, 74 p., 2 pls.

E. Nordenskiöld. Zur Anatomie und Histologie von Ixodes reduvius. Zool. Jahrb. Abt. Morph., XXVII, p. 449–464, plate, 1909.

C. Nörner. Beiträg zur Kenntniss der Milbenfamilie der Dermaleichiden. Verh. zool.-bot. Ges. Wien, 1883, p. 91–106, 2 pls.

G. H. F. Nuttall, C. Warburton, W. F. Cooper, and L. E. Robinson. Ticks, a monograph of the Ixodoidea. Cambridge, London. Two parts issued (Argasidæ and Ixodes), 1908 and 1911.

H. Osborn and L. M. Underwood. Preliminary list of the species of Acarina of North America. Can. Ent., 1886, p. 4–12.

A. C. Oudemans. List of Dutch Acari. 7 parts. Tidsch. voor Ent., XXXIX and XL, 1896–97; and supplements, XLIII to XLV, 1900–1902.

A. C. Oudemans. Notes on Acari.

I. Tijd. v. Ent., vol. 39, p. 175–187, 1897.
II. *Ibid.*, vol. 43, p. 109–128, 1900.
III. Tijd. Ned. Dierk. Ver., (2), vol. 7, p. 50–87, 1901.
IV. *Ibid.*, p. 276–311, 1902.
V. Tijd. v. Ent., vol. 45, p. 123–150, 1903.
VI. *Ibid.*, vol. 46, p. 1–24.
VII. Tijd. Ned. Dierk. Ver., (2) vol. 8, p. 17–34, 1902.
VIII. *Ibid.*, vol. 8, p. 70–92, 1903.
IX. Abh. Nat. Ver. Bremen, vol. 18, p. 77–98, 1904.
X. Mem. Soc. Zool. France, vol. 16, p. 1–32, 1904.
XI. Tijd. v. Ent., vol. 46, p. 93–134, 1904.
XII. Tijd. Ned. Dierk. Ver., (2) vol. 8, p. 202–239, 1905.
XIII. Tijd. v. Ent., vol. 47, p. 114–135, 1905.
XIV. *Ibid.*, vol. 48, p. 1–24, 1905.
XV. *Ibid.*, vol. 51, p. 28–88, 1908.
XVI. *Ibid.*, vol. 49, p. 237–270, 1906.

G. Paoli. Monografia dei Tarsonemidi. Redia, VII, p. 215–281, 4 pls., 1911.

P. J. Parrott. The apples and pear mites. Bul. 283, N. Y. Exper. Station, 1907.

R. Piersig und H. Lohmann. Hydrachnidæ und Halacaridæ. Das Tierreich, 13 Lief., p. 336, 1901.

C. Robin et P. Mégnin. Mémoire sur les Sarcoptides plumicoles. Journ. Anat. et Physiol., 1877, p. 209–248; 391–429; 498–520; 629–656; 10 pls.

D. E. Salmon and C. W. Stiles. The cattle ticks of the United States. 17th Rept. Bur. Animal Ind., U. S. Dept. Agr. (1902), p. 380–491, 257 figs.

K. Samson. Zur Anatomie und Biologie von *Ixodes ricinus*. Zeitschr. f. wiss. Zool., vol. 93, p. 185–236, 4 pls., 18 figs., 1909.

Sig. Thor. Recherches sur l'anatomie comparée des Acariens prostigmatiques. Ann. Sci. Nat. Zool., vol. 19, p. 1–190, 1904.

E. Trouessart. Revue synoptique de la familie des Halacaridæ. Bul. Sci. France et Belgique, XX, p. 225–251, 1889.

E. Trouessart. Considérations générales sur la classification des Acariens. Revue Sci. Nat. de l'Ouest, Paris, 1891, p. 289–308; p. 20–54.

J. B. Tyrrell. On some Canadian ectoparasitic Sarcoptidæ. Journ. Ottawa Field Nat. Club, III, p. 43–48, 1 pl., 1882.

R. H. Wolcott. On the North American species of the genus *Atax*. Trans. Amer. Micr. Soc., XX, p. 193–259, 5 pls., 1899.

R. H. Wolcott. On the North American species of the genus *Curvipes*. Trans. Amer. Micr. Soc., 1901, p. 201–256, 5 pls.

R. H. Wolcott. On the North American species of *Limnesia*. Trans. Amer. Micr. Soc., 1903, p. 139–161, 2 pls.

R. H. Wolcott. A revision of the genera of the water-mites. Trans. Amer. Micr. Soc., 1905, p. 161–243, 10 pls.

INDEX AND GENERIC SYNONYMY.

	Page.
Abrolophus=Belaustium.	
Acanthonotus=Oxypleurites.	
Acarellus=Hypopus.	
Acariasis	128
Acaro-cecidii	135
Acaromantis	56
Acaropsis	27
Acercus	49
Acheles	34
Achiptera=Oribatella.	
Achlysia	47
Achorolophus=Atomus.	
Actineda=Anystis.	
Adactylognatha	16
Adobe tick	65
African coast fever	62
African relapsing fever	62
Agaue	56
Albia	50
Alector=Cepheus.	
Alectorobius	65
Aletes=Rhombognathus.	
Aleurobius=Tyroglyphus.	
Alichus	21
Alichorhagia=Rhagidia.	
Allanalges	122
Alloptes	123
Allothrombium	43
Amblygamasus=Parasitus.	
Amblyomma	68
Ambulacrum	10
Amerobelba=Amerus.	
Ameronothus	96
Ameroseius=Seiulus.	
Amerus	96
Amonia=Cyta.	
Analges	126
Analgesidæ	119
Analloptes	122
Ancystropus	77
Androlaelaps	85
Angelia=Nothrus.	
Angelitos	44
Anoplocelaeno=Celaenopsis.	
Antennocelaeno=Celaenopsis.	
Antennomegistus	87
Antennophorus	86
Anthocoptes	137
Anurania=Arrenurus.	
Anystidæ	30
Anystipalpus	84
Anystis	31
Apectolophus=Erythraeus.	
Aponomma	68
Areola	41
Argas	63

	Page.
Argasidæ	63
Arkan	42
Arpagostoma	16
Arrenurus	50
Ascarus=Dermacarus.	
Astigmata	16
Astomus=Atomus.	
Atacoseius=Podocinum.	
Atax	52
Atelopsalis	56
Atomus	40
Atracheata	16
Atractides	52
Aturus	51
Avenzoaria	122
Axonopsis	50
Banksia	96
Bargena	54
Batata	42
Bdella	25
Bdellidæ	23
Bdellorhynchus	123
Beetle mites	95
Belaustium	41
Belba=Oribata.	
Bird mites	119
Bimichaelia	21
Blackheads	139
Blankaartia=Trombicula.	
Bont tick	69
Boophilus=Margaropus.	
Brachychthonius=Hypochthonius.	
Brachylaelaps=Pachylaelaps.	
Bradybates=Thyas.	
Brain	11
Brevipalpus=Tenuipalpus.	
Bryobia	34
Bud rot	106
Bulb mite	112
Bursa copulatrix	11
Caeculidæ	45
Caeculisoma	41
Caeculus	45
Caelenopsis	80
Caepophagus=Rhizoglyphus.	
Caligonella=Acheles.	
Caligonus	38
Calyptostoma=Smaris.	
Camerostome	9
Campognatha=Hygrobates.	
Canestrinia	118
Canestriniidæ	118
Caparinia	130
Capitulum	57
Carabocepheus=Carabodes.	
Carabodes	98

	Page.
Caris	64
Caroncle	10
Carpais=Parasitus.	
Carpoglyphus	117
Cattle tick	66
Cavannea=Rhyncholophus.	
Cecidobia=Eriophyes.	
Cecidoptes=Eriophyes.	
Celaeno=Trachytes.	
Celaenopsis=Caelenopsis.	
Celeripes=Spinturnix.	
Cellularia=Hypoderas.	
Cephaloneon	134
Cephalouropoda	88
Cepheus	99
Ceratixodes	69
Ceratoacarus=Labidostomma.	
Ceratoppia=Notaspis.	
Ceratozetes=Galumna.	
Cheese mites	112
Chelenotus=Acaropsis.	
Cheletes=Cheyletus.	
Cheletia=Cheyletia.	
Cheletogenes=Cheyletia.	
Cheletoides	28
Cheletominus=Cheyletia.	
Cheletomorpha=Cheyletus.	
Cheletophanes=Cheyletus.	
Cheletopsis	28
Cheletosoma=Cheletopsis.	
Chelicerata	16
Cheyletia	28
Cheyletidæ	26
Cheyletiella	28
Cheyletus	27
Chicken mite	78
Chicken tick	63
Chiloceras=Falculifer.	
Chirodiscus	127
Chorioptes	131
Chortoglyphus	115
Chrithoptes	107
Chyzeria	44
Cilliba	89
Cillibano=Cilliba.	
Claviceps=Galumna.	
Cnemidocoptes	132
Cochleophorus=Neumania.	
Coleopterophagus	119
Coloboceras	55
Conoppia=Liacarus.	
Copidognathus=Halacarus.	
Copriphis	81
Cosmochthonius=Hypochthonius.	
Cosmolaelaps	85
Criniscansor=Myocoptes.	
Crista metopica	41
Crotonus=Ixodes.	
Cryptognathidæ	23
Cryptognathus	23
Cryptostigmata	16
Ctenoglyphus=Glyciphagus.	
Cultroribula=Oribella.	
Cunaxa	25
Curvipes=Piona.	
Cymberemaeus=Cepheus.	
Cynorhaesta	63
Cyrthydrolaelaps	84
Cyrtolaelaps	80
Cyta	25
Cytodites=Cytoleichus.	
Cytoleichidæ	133
Cytoleichus	133
Dactylognatha	16
Damaeus	96
Damaeosoma=Oribata.	
Demodex	139
Demodicidæ	139
Deraiophorus	89
Dermacarus=Labidophorus.	
Dermacentor	67
Dermaleichus=Analges.	
Dermanyssus	78
Dermatocoptes=Psoroptes.	
Dermatodectes=Psoroptes.	
Dermatophagus=Chorioptes.	
Dermatoryctes=Cnemidocoptes.	
Dermoglyphus	122
Deutonymph	73
Deutovum	12
Dimorphus=Megninia.	
Dinothrombium	44
Dinychus	89
Diplodontus	48
Diplostaspis=Spinturnix.	
Diplothrombium	43
Discopoma	88
Discourella=Trachyuropoda.	
Discozercon	82
Disparipes=Scutacarus.	
Distigmata	16
Distigmatus=Tetranychus.	
Diversipes	109
Dog tick	67
Dolaea=Paragreenia.	
Dorsal groove	38
Dromeothrombium=Microtrombidium.	
Ductus ejaculatorius	11
Dugesia=Smaridia.	
Ear tick	65
Earth flea	21
Eatonia=Eatoniana.	
Eatoniana	41
Echiniscus	141
Echinomegistus	87
Ectostracium	12
Elaphrolaelaps=Pachylaelaps.	
Emeus=Hyletastes.	
Enemothrombium=Microtrombidium.	
Entozoon=Demodex.	
Eothrombium=Tanaupodus.	
Epiandrium	10
Epicrius	80
Epidermocoptes	122
Epigynum	10
Epiostracium	12
Epistoma	9
Epitrimerus	137
Eremaeus	95
Eremobelba=Oribata.	
Eremulus=Eremaeus.	
Ereynetes	22
Erineum	134
Erinose	135

	Page.
Eriophyes	137
Eriophyidæ	134
Erythema autumnale	42
Erythacarus=Tarsotomus.	
Erythræidæ	38
Erythraeus	40
Eschatocephalus	68
Eugamasus=Parasitus.	
Euixodes=Ixodes.	
Eulaelaps=Hypoaspis.	
Eulohmannia	96
Eupalopsis=Caligonus.	
Eupalus	24
Eupatra	49
Eupodes	21
Eupodidae	20
Euryparasitus=Cyrtolaelaps.	
Eusarcoptes=Sarcoptes.	
Eustathia	122
Eustigmaeus	38
Eutarsus=Cheyletus.	
Euthesius=Amblyomma.	
Euthyas=Thyas.	
Eutrombidium	43
Euzercon	80
Euzetes=Galumna.	
Eviphis=Hyletastes.	
Expulsory vesicle	11
Eye-capsule	45
Eylais	50
Falculifer	123
Fedrizzia	90
Feltria	53
Fessonia	40
Forelia=Acercus.	
Fowl tick=chicken tick.	
Freyana	122
Frontipoda	54
Fusacarus	118
Gall-mites	134
Galumna	96
Gamasellus	80
Gamasholaspis=Macrocheles.	
Gamasidæ=Parasitidæ.	
Gamasiphis=Parasitus.	
Gamasoides	85
Gamasolaelaps=Parasitus.	
Gamasus=Parasitus.	
Garrapata	65
Gekobia	31
Geayia=Krendowskia.	
Giardius=Tyroglyphus.	
Ginglymosoma	16
Glyciphagus	115
Glycyborus=Glyciphagus.	
Glyphopsis	89
Goniomerus	28
Gonixodes=Haemaphysalis.	
Gonone	42
Greenia=Paragreenia.	
Greeniella Bks.=Paragreenia.	
Greeniella Berl.=Jacobsonia.	
Grocer's itch	112
Gymnobates	98
Gymnodamaeus=Damaeus.	
Haemalastor=Eschatocephalus.	
Haemaphysalis	69
Haemogamasus	78
Haemolaelaps=Laelaps.	
Halacaridæ	54
Halacarus	55
Halarachne	77
Halixodes	54
Haller's organ	58
Halolaelaps=Parasitus.	
Haptosoma=Schizocarpus.	
Harpicephalus=Harpyrynchus.	
Harpirhynchus=Harpyrynchus.	
Harpyrhynchus=Harpyrynchus.	
Harpyrynchus	28
Harvest mite	41
Heart water	62
Hemialges=Megninia.	
Hemisarcoptes	118
Hericia	118
Hermannella=Hermannia.	
Hermannia	102
Heterochthonius=Hypochthonius.	
Heteroglyphus	118
Heteronychus=Tetranychus.	
Heteropus=Pediculoides.	
Heterostaspis=Spinturnix.	
Heterostigmata	16
Heterotracheata	16
Heterozercon	82
Heydeniella=Hydrogamasus.	
Histiogaster	117
Histiostoma	114
Holaspulus=Macrocheles.	
Holocelaeno=Macrocheles.	
Hologamasus	80
Hologastra	7
Hololaelaps=Hypoaspis.	
Holostaspella	81
Holostaspis=Macrocheles.	
Holothyridæ	70
Holothyrus	70
Homopus=Glyciphagus.	
Hoploderma	102
Hoplodermidæ	102
Hoplolaelaps	85
Hoplophora=Hoploderma.	
Hoplopus=Caeculus.	
Hyadesia	118
Hyalomma	66
Hydracarus=Hydrachna.	
Hydrachna	53
Hydrachnidæ	45
Hydrarachna=Hydrachna.	
Hydrochoreutes	53
Hydrodoma=Hydryphantes.	
Hydrogamasus	80
Hydryphantes	49
Hygrobates	52
Hyletastes	81
Hypoaspis	85
Hypocthoniella=Hypochthonius.	
Hypochthonius	101
Hypodectes	125
Hypoderas	125
Hypoderm	12
Hypopus	110

	Page.
Hypostome	9
Ichoronyssus=Liponyssus.	
Imparipes	109
Iphidoides=Hyletastes.	
Iphidosoma=Poecilochirus.	
Iphiopsis	81
Iphis=Hyletastes.	
Itch-mites	128
Ixodes	69
Ixodidæ	56
Jacobsonia	81
Janetiella=Trachyuropoda.	
Johnstoniana	43
Jugularia	71
Kedani	42
Koenikea	52
Krameria=Pterolichus.	
Krendowskia	50
Labidocarpus	127
Labidophorus	115
Labidostomma	103
Labidostommatidæ	103
Laelaps	84
Laelaspis	85
Laelogamasus=Parasitus.	
Lais=Pediculoides.	
Lamella	90
Laminosioptes	133
Lebertia	52
Leiognathus=Liponyssus.	
Leionotus=Hypoaspis.	
Leiosoma=Liacarus.	
Leiostaspis=Ancystropus.	
Lentungula=Hyadesia.	
Leonardiella=Trachyuropoda.	
Lepidozetes=Galumna.	
Lepronyssus=Liponyssus.	
Leptognathus	56
Leptospathis=Halacarus.	
Leptothrombium=Eutrombidium.	
Leptus	42
Leucoppia=Liacarus.	
Liacarus	98
Limnesia	51
Limnochares	50
Linguatula	140
Linguatulidæ	140
Linobia	119
Linopodes	21
Liodes=Neoliodes.	
Liponyssus	78
Lipostigmata	16
Liroaspis=Sejus.	
Listrophoridæ	126
Listrophorus	127
Lohmannia	96
Lone star tick	68
Lophoptes	79
Louping ill	69
Lucasiella=Eatoniana.	
Macrobiotus	141
Macrocheles	81
Macrostigmaeus	38
Malaconothrus	96
Malignant jaundice	62
Mange	128
Margaropus	66
Mediolata=Caligonus.	
Megalolaelaps=Hypoaspis.	
Megamerus=Eupodes.	
Megapus=Atractides.	
Megisthanus	80
Megninia	126
Melichares	85
Meristaspis=Spinturnix.	
Mesoplophora	102
Mesostigmata	16
Metapodia	71
Metasternalia	71
Metastigmata	16
Miana bug	63
Michaelia Berlese=Bimichaelia.	
Michaelichus=Freyana.	
Micreremus=Cymberemaeus.	
Microcheles=Zercon.	
Microlichus	123
Microspalax=Freyana.	
Microtrombidium=Belaustium.	
Mideopsis	51
Molgus	25
Monieziella	116
Monostaspis=Spinturnix.	
Moubata bug	65
Murcia=Galumna.	
Musitania=Diplothrombium.	
Myobia	29
Myocoptes	127
Myrmonyssus=Myrmozercon.	
Myrmozercon	84
Najadicola	49
Nanorchestes	22
Nautarachna	48
Neoberlesia	80
Neocelaeno=Cælenopsis.	
Neoliodes	99
Neomegistus	87
Neoparasitus=Hydrogamasus.	
Neophyllobius	34
Neopodicium=Macrocheles.	
Neotrombidium=Microtrombidium.	
Neozetes=Serrarius.	
Neumania	52
Neumanniella=Aponomma.	
Nicoletia=Labidostomma.	
Nicoletiella=Labidostomma.	
Nodipalpus=Histiostoma.	
Norneria=Rhagidia.	
Notaspis	98
Nothrus	99
Notoedres	131
Notophallus	21
Nycteridocoptes=Prosopodectes.	
Nymph	12
Nympho-chrysalis	43
Octostigmata	16
Ocypetus	42
Olecranon process	119
Oligonychus=Tetranychus.	
Ologamasus=Hologamasus.	
Olopachys=Pachylaelaps.	
Onchodellus=Pachylaelaps.	
Oolaelaps=Hypoaspis.	

	Page.
Ophiodes=Aponomma.	
Ophiomegistus	87
Ophionyssus	78
Opilioacarus	140
Opisthodon=Haemaphysalis.	
Opisthope=Trachyuropoda.	
Oplitis=Uroplitella.	
Oppia	96
Oral tube	9
Oribata	99
Oribatella	96
Oribatidæ	95
Oribatodes	95
Oribatula	95
Oribella	98
Oripoda	98
Ornithodoros	64
Otobius	65
Otocepheus=Carabodes.	
Otodectes	132
Otonyssus	44
Ottonia=Belaustium.	
Oustaletia=Pterolichus.	
Oxus	54
Oxypleurites	137
Pachylaelaps	80
Pachyseius=Pachylaelaps.	
Pajahuellos	64
Panisus	48
Panoplia=Labidostomma.	
Paragreenia	84
Paralges=Dermoglyphus.	
Paramegistus	87
Parantennulus	87
Parapodia	71
Parasitidæ	71
Parasitus	85
Parateneriffia	23
Parhypochthonius=Tripochthonius.	
Parthenogenesis	13
Pear mite	137
Pediculoides	106
Pediculopsis	106
Pelops	98
Pelopsis=Galumna.	
Peloptulus=Pelops.	
Peloribates=Galumna.	
Penthaleus	21
Peplonyssus	44
Pergamasus=Hologamasus.	
Perigenital plate	88
Periglischrus	76
Peritremata	16
Peritreme	72
Petrobia=Bryobia.	
Phauloppia=Liacarus.	
Phaulixodes=Ixodes.	
Philodromus=Tydeus.	
Phthiracarus	102
Phycobius=Carpoglyphus.	
Phyllerium	134
Phyllocoptes	137
Phyllostoma=Histiostoma.	
Physalozercon	87
Physogaster=Pediculoides.	
Phytocoptes=Phyllocoptes.	
Phytoptose	135
Phytoptus=Eriophyes.	
Phytotipalpis	38
Picobia	30
Pigmeophorus	107
Pimeliaphilus	38
Pimelobia	108
Pinolias	65
Piona	53
Piracarus=Uroplitella.	
Plateremaeus	96
Platylaelaps=Pachylaelaps.	
Plutarchia=Thecarthra.	
Pneumonyssus	77
Podapolipus	108
Podocinum	84
Podoribates=Galumna.	
Podothrombium	43
Poecilochirus	85
Polyaspis	89
Pontarachna	48
Porocephalus	140
Porose areas	57
Porrhostaspis=Gamasus.	
Porrothus=Carabodes.	
Proctophyllodes	123
Prosoma	8
Prosopodectes	132
Prosopodon=Haemaphysalis.	
Prosopon	12
Prostigmata	16
Protalges	122
Protolichus=Pterolichus.	
Protonymph	73
Protoplophora	102
Protoribates=Oribatodes.	
Protzia=Thyas.	
Pseudalloptes	122
Pseudixodes=Dermacentor.	
Pseudocheylus	25
Pseudoparasitus=Hypoaspis.	
Pseudo-stigmatic organ	90
Psorergates	28
Psoroptes	131
Pteralloptes	126
Pterocolus=Trouessartia.	
Pterodectes	122
Pterolichus	123
Pteronyssus	126
Pterophagus=Pterodectes.	
Pteroptus=Spinturnix.	
Pterygosoma	31
Ptilonyssus	77
Ptocharus	87
Punctoribates=Galumna.	
Pycnogonida	141
Raillietia	82
Raphignathus	34
Red bug	42
Red spiders	32
Red water	62
Rhagidia	22
Rhinonyssus	77
Rhinothrombium=Tanaupodus.	
Rhipicentor	68
Rhipicephalus	68

	Page.
Rhipistoma=Haemaphysalis.	
Rhizoglyphus	116
Rhodocarus	80
Rhombognathus	56
Rhyncholophus=Erythraeus.	
Rhynchoprion=Argas.	
Rhynchothrombium=Tanaupodus.	
Ricini	63
Ritteria=Rhyncholophus.	
Rivobates=Hygrobates.	
Rivoltasia	123
Rouget	42
Saproglyphus=Monieziella.	
Sarcoborus=Harpyrynchus.	
Sarconyssus=Haemalastor.	
Sarcopterinus=Harpyrynchus.	
Sarcopterus=Harpyrynchus.	
Sarcoptes	130
Sarcoptidæ	128
Scabies	128
Scaly leg	132
Scapheremaeus=Cymberemaeus,	
Scaptognathus	56
Scheloribates=Galumna.	
Schistosoma=Megninia.	
Schizocarpus	127
Scirula	24
Scirus	25
Scleroderma	16
Scutacarus	108
Scutovertex	98
Scyphius=Rhagidia.	
Seed ticks	60
Seiodes	80
Seiulus	85
Sejus	81
Sericothrombium=Trombidium.	
Serrarius	95
Serrator=Histiostoma.	
Sessiluncus=Gamasellus.	
Sheep scab	131
Silver top	106
Simognathus	56
Simonea=Demodex.	
Siteroptes	107
Smaridia=Fessonia.	
Smaris	40
Spelaeorhynchus	70
Speleorchestes	22
Sperchon	51
Spermatheca	11
Sphaerochthonius=Hypochthonius.	
Sphaerogyna=Pediculoides.	
Sphaerolælaps=Pachylaelaps.	
Sphaerolophus=Rhyncholophus.	
Sphaeroseius=Hypoaspis.	
Sphaerozetes=Oribatella.	
Spinturnix	76
Spirochaetosis	64
Spotted fever	67
Steatozoon=Demodex.	
Steganaspis=Arrenurus.	
Sternostomum	77
Stigmaeodes	38
Stigmaeopsis	38
Stigmaeus	37
Stilochirus=Laelaps.	
Stylocerata	16
Suctobelba=Oribata.	
Sugar mite	112
Symbiotes=Chorioptes.	
Symplectoptes=Laminosioptes.	
Syncaligus=Acheles.	
Syringobia	122
Syringobial stage	30
Syringophilus=Picobia.	
Tachybates=Eupodes.	
Tanaognathus	48
Tanaupodus	43
Tardigrades	140
Tarsolarkus	109
Tarsonemidæ	104
Tarsonemus	108
Tarsotomus	31
Tectocepheus	95
Tectopedium	90
Tegeocranus	99
Tegonotus	137
Teleiochrysalis	43
Teneriffia	23
Teneriffiola=Teneriffia.	
Tenuipalpus	34
Tetranobia	38
Tetranychidæ	32
Tetranychina	38
Tetranychoides	38
Tetranychopsis	34
Tetranychus	35
Tetrapoda	16
Texas fever	67
Thalassarachna	55
Thecarthra	122
Thrichocylliba=Cilliba.	
Thyas	50
Thyopsis	52
Ticks	56
Tinoglischrus=Spinturnix.	
Tlalsahuate	42
Tomogastra	8
Torynophora=Bryobia.	
Trachygamasus=Parasitus.	
Trachynotus=Trachytes.	
Trachytes	89
Trachyuropoda	90
Tricheremaeus=Notaspis.	
Trichobius=Trichoecius.	
Trichodactylus=Trichotarsus.	
Trichoecius	127
Trichoribates=Oribatella.	
Trichotarsus	117
Trimerus=Epitrimerus.	
Tripochthonius	99
Tristaspis=Periglischrus.	
Tritia=Phthiracarus.	
Tritonymph	73
Trizetes	102
Trombella	44
Trombicula	43
Trombidiidæ	41
Trombidium	43
Trouessartella	55
Tumidalvus=Tripochthonius.	

	Page.
Turicata	65
Tydeus	21
Typhlothrombium	43
Tyroglyphidæ	109
Tyroglyphus	116
Tyrrellia	52
Unionicola=Atax.	
Urodinychus=Trachyuropoda.	
Urodiscella=Uroplitella.	
Uroobovella	88
Uroplitella	88
Uropoda	88
Uropodella	90
Uropodidæ	87
Uroseius	88
Urosternella=Uropoda.	
Urotrachytes=Glyphopsis.	
Vasa deferentia	11
Vasates=Eriophyes.	
Vermiformia	16
Volvolifex	134
Water-mites	45
Witch's broom	135
Xemiostigmata	16
Xenillus=Notaspis.	
Xiphiastor=Amblyomma.	
Xolalges	122
Xoloptes	122
Xystonotus	51
Zercon	80
Zetes=Galumna.	
Zetorchestes=Leptorchistis.	
Zschokkea=Thyas.	

ADDITIONAL COPIES

OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT

30 CENTS PER COPY